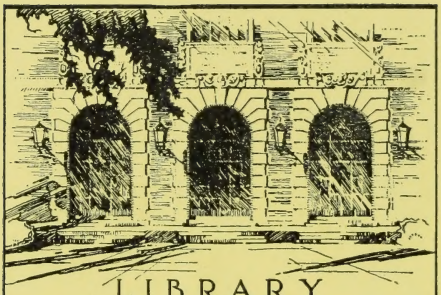

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THE COMPOSITION AND DYNAMICS OF A BEECH-MAPLE CLIMAX COMMUNITY

By

Arthur B. Williams, Ph.D.

SCIENTIFIC PUBLICATIONS
OF THE
CLEVELAND MUSEUM OF NATURAL HISTORY
Volume VI

First Printed in ECOLOGICAL MONOGRAPHS
Vol. 6, No. 3, July 1936

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By

ARTHUR B. WILLIAMS
Cleveland Museum of Natural History

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[1] Contribution from the Biological Laboratory of Western Reserve University.

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THE COMPOSITION AND DYNAMICS OF A BEECH-MAPLE CLIMAX COMMUNITY

INTRODUCTION

The approach in this study is to the biotic community as a whole. It is sought to determine both its plant and animal content; the number and abundance of species; their relations to each other and to the community as a whole; seasonal and yearly variations in numbers and activities; territorial relations; food relations; the stage of succession represented; changes now going on; environmental conditions, including soil and climatic factors; and the effect of these upon the community.

Special emphasis is laid upon the vertebrates and the major plant forms. While it has not been possible to treat the invertebrate life as fully as the plants and vertebrates, some invertebrates have been noted, and are included in this paper.

The writer desires here to acknowledge his indebtedness and to express his appreciation to the Cleveland Metropolitan Park Board for the opportunity afforded for this study within the Cleveland Metropolitan Park System, and for many courtesies extended by park officials; to the Cleveland Museum of Natural History for making this study possible as a piece of research in connection with its program, and to Mr. Harold L. Madison, Director of the Museum, for encouragement in it; to Dr. J. Paul Visscher, Chairman of the Department of Biology of Western Reserve University, for the privilege of coördinating a study of this kind with the regular work of the Department, and especially to Dr. S. C. Kendeigh, of the Department of Biology of Western Reserve University, for his many helpful suggestions and criticisms during the progress of the work and the preparation of this paper.

The writer's thanks are also due to Dr. Addie E. Piehl of the Department of Biology of Western Reserve University for aid in identifying mosses, lichens, and algae; and to Mr. Henry M. Beardslee, of North Perry, Ohio, for similar aid in identifying fungi. To Mr. B. P. Bole, Jr., mammologist of the Cleveland Museum of Natural History, and to Dr. Harry C. Oberholzer, of the United States Biological Survey, the writer is indebted for checking the lists of mammals and of birds, respectively, with special reference to subspecies names. To Mr. Arthur B. Fuller, of the Cleveland Museum of Natural History, to whose expert marksmanship the collection of all of the bats taken in the area is due (for which special permission was given by the Park Board for the purposes of this study), the writer is also indebted. To Mr. Philip Moulthrop, also of the Cleve-

land Museum of Natural History, the writer is indebted for much help in the collection of small mammals.

It is not maintained that this study is now complete. In a sense it might be carried on indefinitely and never be complete. It seems desirable, however, at this time to make available the data thus far collected and to report the findings.

The beech-maple forest (Fagus-Acer association) is an important ecological division of the deciduous forest formation, which formation at the coming of the white man occupied so large a part of the northeastern United States and southern Canada. The deciduous forest has been described by Transeau (1905), Harshberger (1911), Frothingham (1915), Clements (1916), Livingston and Shreve (1921), Shantz and Zon (1924), and Weaver and Clements (1929). Weaver and Clements give the limits of the deciduous forest formation as running on the north from central Minnesota along the south shore of Lake Superior eastward to southwestern Quebec and southern Maine, thence stretching southward into central Georgia, southern Louisiana, and eastern Texas. The same authors regard the beech-maple forest as the "typical association" of the deciduous forest formation, "characterizing its more humid and cooler northern and eastern portions."

The plant structure of the beech-maple association has been studied in detail in southern Michigan by Quick (1923) and by Cain (1935), in northern Michigan by Gleason (1924), and in Indiana by Esten (1932). In Ohio the beech-maple association is emphasized by Sampson (1927) as one of the four primary plant communities in the state on the basis of area covered. Sears (1925), attempting to reconstruct the picture of the natural vegetation of Ohio before the advent of the white man noted that beech, unmixed with oak or ash, was practically limited to the glaciated region of the state. References to the occurrence of both beech and sugar maple throughout their range will be found in the Naturalists' Guide to the Americas, edited by Shelford (1926).

Hemlock is recognized as a frequent constituent of the beech-maple association (Gleason 1924, Weaver and Clements 1929). The hemlock forest has been described by Lutz (1930) and the environmental requirements of hemlock studied by Moore, Richards, Gleason and Stout (1924).

The animal content of the forest, the relationships between plants and animals, and the consideration of the biotic community as such have not thus far been given the consideration accorded to the plant constituents of the community. Important contributions have been made in this country by Adams (1906), Shelford (1913), and Chapman (1931); and in England by Elton (1927, 1930). The mammals of a beech-maple forest in Michigan have been listed by Dice (1920), and an ecological survey of Isle Royale conducted by Adams (1909) included a study of animals found there.

The insect life of an elm-maple forest in Illinois has been studied in detail by Weese (1924), and much the same thing has been accomplished by Blake (1926), working on Mount Katahdin in Maine. A study of the biotic communities of the aspen parklands of central Canada was made by Bird (1930). Shelford and Olsen (1935) have pointed out the relation which animals may have to plant communities as indicators, and maintain that plants and animals are inseparably united in the structure of any community. Much painstaking labor has been devoted to the study of various phases of animal ecology by numerous workers, but there is little in the literature that treats of forest communities as biotic units.

DESCRIPTION OF AREA STUDIED

Location and Physiography

To the northeast of Cleveland, Ohio, and some 16 miles from the city limits, lies the tract of land known as the North Chagrin Reservation of the Cleveland metropolitan park system. It contains 1,201 acres (486.04 hectares), and is roughly rectangular in shape, being approximately a mile and a half (2.41 kilometers) square (Board of Park Commissioners, Report 1932-1933). It lies between parallels 41° 33′ and 41° 35′ north latitude.

The reservation occupies a position at the extreme edge of Appalachian Plateau, as the Portage Escarpment which limits the plateau in this region is represented by the high bluffs of the Chagrin River valley which are a part of the area. The location is well within the boundaries of the advance of the ice sheets of Pleistocene times (Cushing, Leverett, and Van Horn 1931). Lake Erie is distant about 5 miles (8.04 kilometers) in a direct line toward the northwest.

Within the reservation the land slopes gently toward the east for about a mile (1.6 kilometers), where it drops steeply almost to the level of the river. This bluff which marks the border of the valley is deeply and frequently cut by short gullies and ravines only a few of which are extensive enough to carry water all the year. The United States topographical survey map (Mentor Quadrangle) shows the difference in level between the western margin of the reservation and the river to be 220 feet (67.05 meters).

The particular area chosen for this study lies along the southern boundary of the North Chagrin Reservation. It is approximately 65 acres (26.3 hectares) in extent, is entirely wooded, and includes some of the characteristic gullies, ravines, and bluffs of the locality. It does not include any of the river bottom or lower lands. It slopes toward the northeast from 860 feet (262.12 meters) to 760 feet (231.64 meters) above sea level. In outline it is somewhat irregular, because of the nature of the ground, except at its southern and western limits. It is traversed by several foot-trails and

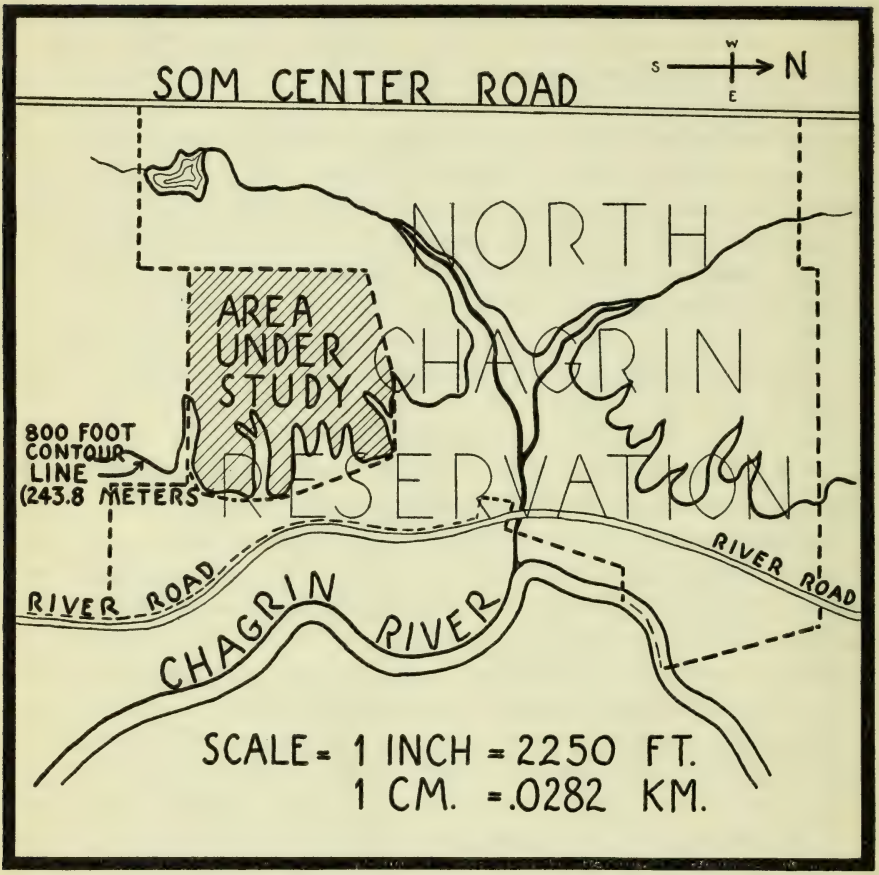

FIG. 1. Map of North Chagrin Reservation showing location of area under study.

bridle-paths which greatly facilitate quiet and easy access to all of its parts. Reference to Figure 1 will give an idea of the topography of the area and of its relation to the entire North Chagrin Reservation. It should be noted that the reservation is not an isolated piece of forest land. While to the west the country is occupied by farms, the adjoining land to the north and south and across the river to the east is largely of the same character as that of the reservation itself.

GEOLOGY AND SOIL

The geological formation immediately underlying the surface soils is that known as the Cleveland Shale. This is a sedimentary rock apparently composed of consolidated black mud (Cushing, Leverett, and Van Horn 1931). Upon this bed-rock of shale a layer of soil of glacial origin known as the Volusia Clay Loam has been deposited. Coffey and Rice (1912), describing this soil, say: "As a general rule, both soil and subsoil are markedly

deficient in lime carbonate, and will redden litmus paper quickly. The Volusia series is derived from glacial deposits of shale and sandstone material which covers the northeastern section of Ohio." The Volusia Clay Loam is a poorly drained soil, and not among the more productive soils of the State. The presence of beech trees is said to be characteristic of the Volusia series. Over the clay loam above described there has been built up a layer of humus of a loose and spongy character from 1 to 4 inches (2.54 to 10.16 cm.) in depth. The clay soil beneath the humus is not more than from 4 to 9 inches (10.16 to 22.86 cm.) deep, but it is friable and porous as compared with the subsoil, which is of dense yellow clay.

Drainage

Because of the heavy quality of the underlying sub-soil, standing water, in hollows, after rains or melting snows, is of common occurrence on the more level parts of the area. Depressions left by the uprooting of large trees will sometimes contain water most of the year if precipitation is fairly regular. In winter and spring the woods of the higher or more westerly part of the area are always wet. Aside from such water as may collect in depressions or pockets, the run-off of excess water is rapid. Within the area there are no constant streams, the waterways with one exception being short and the gradient steep. One waterway, having its collecting basin in the open fields outside the area, and traversing its higher portion in more leisurely fashion, does not become entirely dry except after periods of prolonged drought.

CLIMATE

The close proximity of Lake Erie may be considered as a factor modifying to some extent the climate of the region. In general, as has often been pointed out, temperatures do not rise so high nor fall so low near the lake as they do farther inland. The lake also is often responsible for a condition of cloudiness that cuts down very appreciably the amount of available sunshine (Moseley 1897).

In order to secure positive information as to the factors of temperature, humidity, and precipitation within the area, four stations were established and their operation begun on January 1, 1932. Two of these stations, designated as "A" and "B," were located in beech maple environment. The other two, designated as "C" and "D," were located in beech-hemlock environment. At Station A a hygrothermograph giving continuous records of temperature and relative humidity was installed in a wooden shelter resting on the ground. A rain gauge, by means of which precipitation over a circular area 3 inches (7.62 cm.) in diameter may be measured in hundredths of an inch, was located here. At Stations B, C, and D, maximum and minimum thermometers and rain gauges similar to that at Station A were in-

stalled. The thermometers were secured to the north sides of large trees about 5 feet (1.52 meters) from the ground, and the rain gauges located beneath the same trees from 6 to 10 feet (1.82 to 3.04 meters) from their bases. Readings from all instruments were taken with regularity weekly, and the operation of the hygrothermograph regularly checked as to temperature with a tested thermometer, and as to relative humidity with a cog psychrometer. The thermometers were compared at different temperatures, and their readings found to be in agreement. Their accuracy was also checked with a standard thermometer.

TEMPERATURE

Figure 2 shows the mean temperature by weeks, on the basis of hourly readings, at Station A for the year 1932. To this has been added the records of mean temperature for the same weeks as recorded by the Cleveland Weather Bureau, and also the curve of normal temperature for Cleveland. It will be noted that the means for Cleveland follow closely the fluctuations recorded at North Chagrin. It is thus possible to construct a table of corrections for the Cleveland figures which may be used for further temperature studies at North Chagrin. Table 1 shows these corrections. It is apparent that the appearance of the leaves on the trees, and the development of a full and dense cover of foliage, which takes place from the middle of May to the middle of June is a definite factor in modifying temperatures in

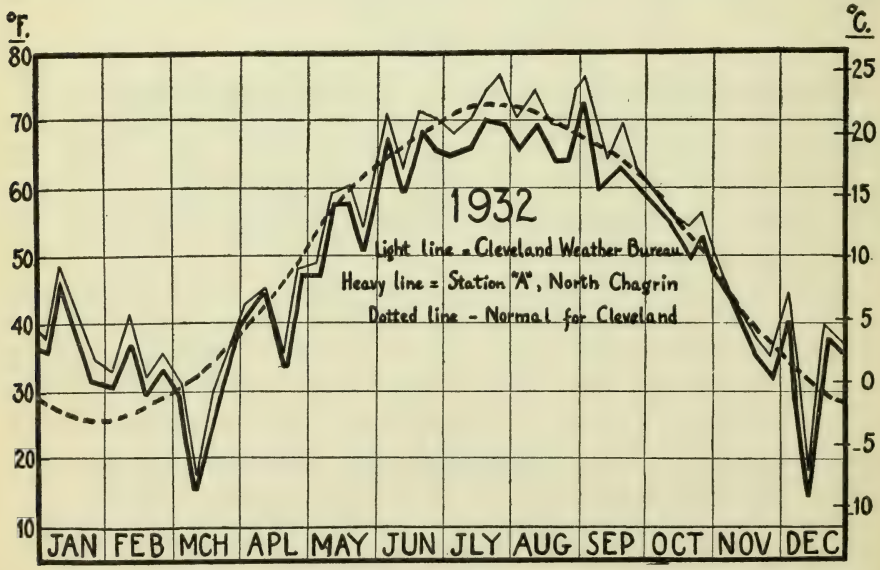

FIG. 2. Mean temperature by weeks on the basis of hourly readings at station "A," 1932, with mean temperature recorded for the same period by the Cleveland Weather Bureau. Curve of normal temperature for Cleveland.

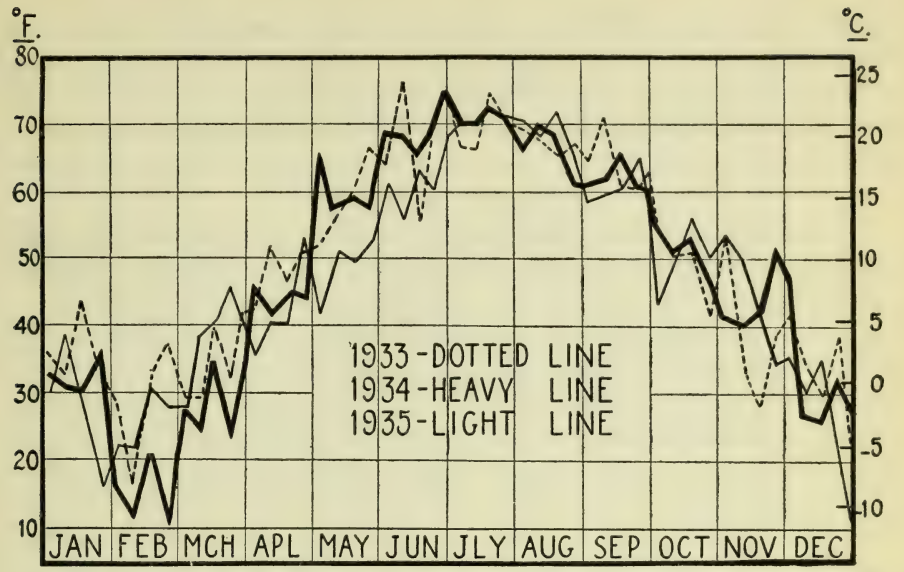

Fig. 3. Weekly mean temperature at North Chagrin, 1933, 1934, and 1935, from Cleveland Weather Bureau figures corrected in accordance with table 1.

the beech-maple forest. The Cleveland station of the U. S. Weather Bureau gives 200 days as the length of the growing season in this locality.

By the use of the correction figures (Table 1) the mean weekly temperatures at North Chagrin for the years 1933, 1934, and 1935 are shown not to be greatly different from those of 1932 (Fig. 3). Differences in temperatures recorded at the 4 stations were not great enough to be considered especially significant. After the middle of May when the leaves were on the trees there was little or no difference in the minima and but slight difference in

Table 1. Differences between temperatures at Cleveland and at North Chagrin, 1932, averaged for each month, and figures used for correcting Cleveland temperature records to show conditions at North Chagrin. (1° F. = 0.56° C.).

Month	Weekly Mean		Weekly Maximum		Weekly Minimum	
	Actual Difference	Correction Figure	Actual Difference	Correction Figure	Actual Difference	Correction Figure
January	—2°F.	—2°	—2°F.	—3°	—1°F.	—1°
February	—3	—2	—5	—3	—2	—1
March	—2	—2	—4	—3	—4	—4
April	—1	—2	0	—3	—3	—4
May	—2	—2	—1	—3	—4	—4
June	—4	—4	—3	—3	—6	—6
July	—5	—5	—5	—5	—4	—6
August	—5	—5	—6	—6	—6	—6
September	—4	—4	—6	—6	—9	—6
October	—3	—3	—4	—4	—3	—3
November	—2	—2	—3	—4	—3	—3
December	—2	—2	—4	—4	—1	—1

the maxima of all stations, 4° being the greatest divergence recorded. It may be said, then, that temperature in the area at five feet above the ground is practically uniform throughout, whether in beech-maple or in beech-hemlock environment, except as affected in minor ways by exposure or shelter.

Relative Humidity

Figure 4 shows the weekly means of the records of relative humidity on the basis of hourly readings at Station A for the year 1932. The mean relative humidity for the year was 83.3 per cent. When a comparison by weeks is made it appears that with few exceptions the amount of relative humidity was generally between 75 and 90 per cent. Records of many hours showed frequent periods of 100 per cent. A notable exception occurred during the latter part of April, a time of low precipitation, when great extremes of humidity were recorded daily, the record fluctuating between 16 and 100 per cent.

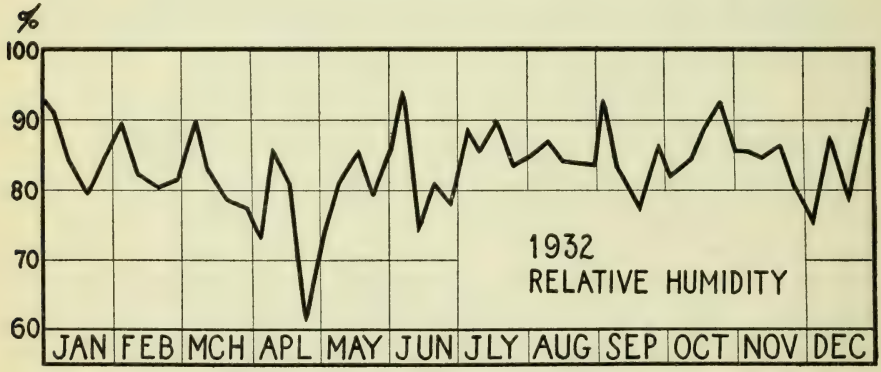

Fig. 4. Mean relative humidity by weeks on the basis of hourly readings, station "A," 1932.

Precipitation

Records of amount of precipitation were obtained weekly during 1932 at all 4 stations. The individual instruments at times varied somewhat as to amount of water collected, but in the long run they approximated fairly closely (Table 2).

Table 2. Total precipitation at 4 stations: January 1 to December 31, 1932.

Station A	— beech-maple	— 31.70 inches	(80.52 cm.)
Station B	— beech-maple	— 32.41 inches	(83.32 cm.)
Station C	— beech-hemlock	— 29.23 inches	(74.24 cm.)
Station D	— beech-hemlock	— 29.11 inches	(73.94 cm.)

If the records of the two stations in beech-maple environment be averaged, and compared with the average of the two stations in beech-hemlock environment, it appears that the hemlocks received 2.88 inches (7.31 cm.) less water about their roots during the year than did the deciduous trees.

Since so little variation in precipitation was shown between the stations, the taking of further precipitation records was continued at Station B only. The records at this station by months for the 4 years of this study is shown in Figure 5, use being made of the diagrammatic method first introduced by Transeau in 1931 (Cain 1932). A study of these precipitation patterns discloses the fact that in 1932, during the growing season and immediately before, precipitation was very light, and that again in 1933 conditions during the growing season were marked by a deficiency of moisture. In fact, such rain as did fall in the summer of 1933 was concentrated in a few downpours which, because of the rapid run-off and speedy evaporation, was very ineffective, hardly reaching the soil beneath the forest litter to any great extent.

The year 1934, however, proved to be one in which precipitation, though deficient in May, was above normal in the summer and autumn, although this was the year of the great drought in other parts of the country. Because this record seems unusual it is fortunate that records of precipitation are available for the summer and early autumn of this year from the farm of Mr. B. P. Bole at Kirtland Hills, about 6 miles (9.65 kilometers) to the northeast, as a check upon the North Chagrin records. As a further check 2 additional rain gauges were operated in the spring of 1935 on either side of the North Chagrin instrument and about 10 feet (3 meters) away from it. Over a period of 4 weeks all three instruments were found to be in accord. For purposes of comparison the Bole farm records and those of the Cleveland Weather Bureau for 1934, as well as the normal precipitation for Cleveland, are included in Figure 5. As a matter of general observation it may be said that weather conditions at Cleveland and at North Chagrin are frequently not the same.

Wind

That the forest is responsible in many ways for its own micro-climate is strikingly shown in the way in which the movement of wind within its borders is modified by the presence of trees and other plants both in summer and in winter.

Toward the west the edge of the forest under study is bordered by an open field, and so presents an unbroken front to the full force of the wind from this direction. At this point, readings with an anemometer of the "windmill" type, measuring the velocity of the wind in feet, were taken over periods of 5 minutes each, first outside the forest, to measure the force of the wind at this point, and at each succeeding 100 feet (30.48 meters) within the forest, following the direction of the wind, until a point 1,000 feet (304.8 meters) from the edge was reached. The velocity of the wind at the outside was then again measured, and the average of this, and the first outside measurement taken as the velocity of the wind during the hour or more consumed in taking all of the records. Six such

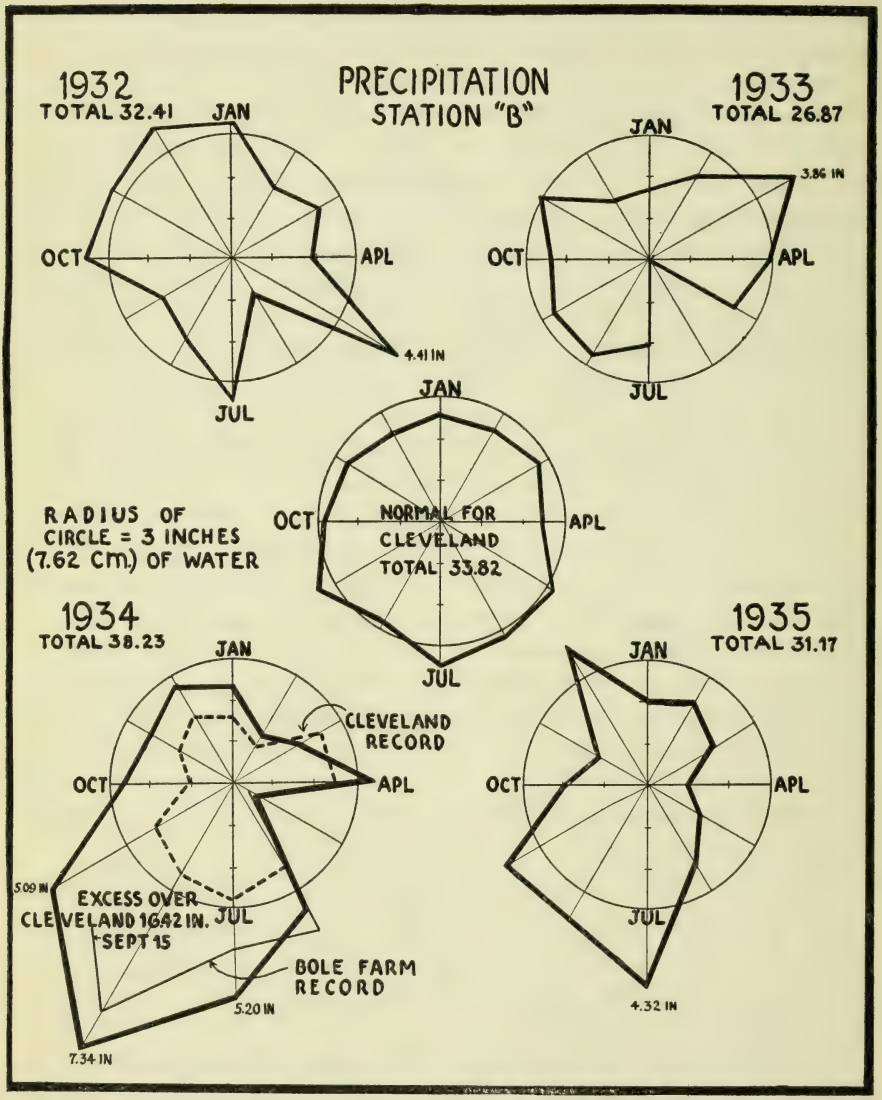

FIG. 5. Precipitation by months, station "B," 1932, 1933, 1934, and 1935, with Bole Farm records and Cleveland records for 1934, and normal for Cleveland.

complete records were obtained at various times and under various conditions when the trees were bare of foliage, and five complete records when the trees were in full leaf. Table 3 shows the amount of decrease in velocity after reaching the 800-foot mark. Records are reduced to feet per minute.

Reduced to percentages of decreased velocity from the forest edge inward, the results of these records are given in Figure 6. The records from the 700-foot point and further were usually of light and shifting air cur-

Table 3. Effect of forest on wind velocity.
(records in feet per minute)

Trees Without Leaves			Trees With Leaves		
Record	Average velocity in open	Average velocity 800-1000 ft.	Record	Average velocity in open	Average velocity 800-1000 ft.
1.	862 f.p.m.	161 f.p.m.	1.	763 f.p.m.	47 f.p.m.
2.	826	168	2.	573	22
3.	671	111	3.	481	27
4.	615	172	4.	343	23
5.	495	175	5.	284	64
6.	339	159			

Note: 100 feet = 30.48 meters.

rents. Several readings taken further within the forest showed essentially the same conditions. Comparing summer and winter conditions it appears that there is from six to seven times more air in motion near the ground in winter than in summer.

Sunshine

Figure 7 shows the possible number of hours of sunshine by months for Cleveland, and also the actual number of hours of sunshine for the year 1932. For purposes of comparison the curve of the normal number of hours of sunshine for Cleveland is included. It is apparent that the total amount of cloudiness during the year is very considerable. Even though there were actually more hours of sunshine than normal in 1932 for 8 months out of 12, the actual number of hours of sunshine for the year were only 56 per cent of the possible number—the normal being 52 per cent. During the winter months, December, January, and February, the normal proportion of sunshine sinks to 24, 29, and 35 per cent of the possible number of hours.

While no measurements of light intensities were made, it should be noted that the beech-maple-hemlock forest is a dark forest in summer. One of the first things of which one becomes conscious upon entering this forest on a bright summer day, is of the great decrease of light intensity. The eyes need to become adjusted to this condition before much can be seen. The writer has frequently made exposures of 15 seconds duration on photographic film in order to get good pictures within the forest on days when the summer sun was shining brightly outside. Using the same aperture, lens, and film in the open on such a day would have necessitated an exposure of one-fiftieth of a second. Although this is by no means an exact measurement, it does indicate that light within the forest is one-seven-hundred-and-fiftieth as effective on photographic film in midsummer as it is outside the forest at the same time and otherwise under the same conditions.

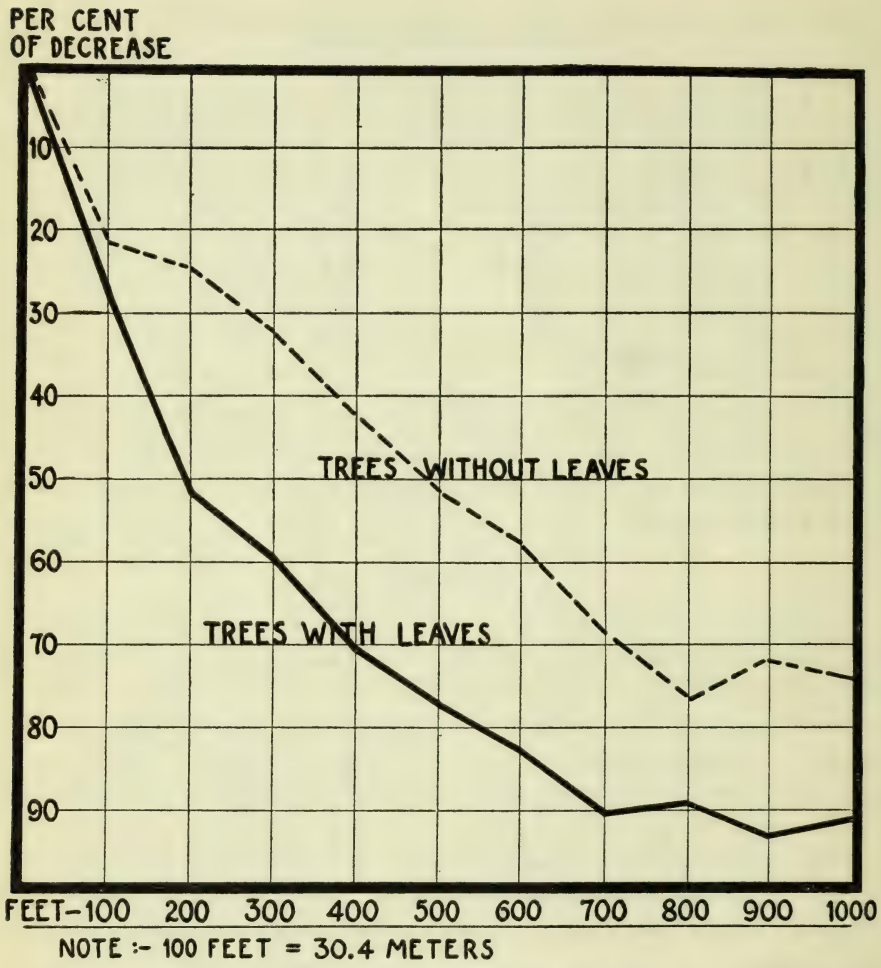

FIG. 6. Decrease in velocity of wind from forest edge inward in summer (heavy line) and winter (dotted line).

EVAPORATION RATE

During the summer of 1934 an attempt was made to secure data on the rate of evaporation of moisture, both in the forest, and in the open just outside the woods to the west. For this purpose standardized Livingston porous clay bulb atmometers were used, evaporating distilled water only. Although a group of three instruments were run in the woods, so that readings might be averaged, continual interference with the bulbs by gray squirrels, and the growth of protococcus on the bulbs at times, reduced the number of available instruments often to two, and sometimes to one. There were also two short periods when all instruments in the woods were out of

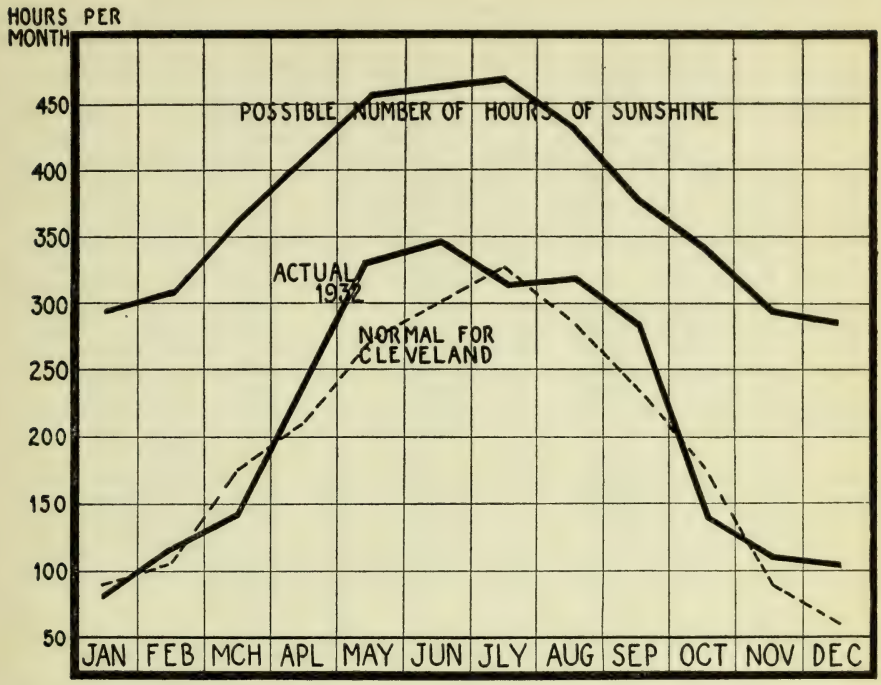

Fig. 7. Possible and actual number of hours of sunshine for Cleveland in 1932, and normal for Cleveland.

commission due to these causes. The one instrument in the open field ran continuously without interruption from August 1 to October 15 when the bulb was shattered by freezing. To get some idea of winter conditions, readings were taken twice over short periods in November and January when the temperature was above freezing. Table 4 gives the data obtained from these instruments.

The rate of evaporation is apparently affected greatly by various atmospheric conditions. Wind greatly increases it. Precipitation in summer and freezing in winter slows it up. High temperature with dryness is conducive to a high evaporation rate. The effect of the forest in reducing the rate of evaporation within its borders, as compared with conditions in the open, is striking, showing an average difference of 55.2 per cent in summer when the leaves are on the trees, and of 38 per cent in winter when the forest is more exposed to the influence of wind.

Summary of Climatic Data

From the data gathered over the four-year period of this study, the climate of the area may be summarized by saying that temperatures are not extreme, varying from -13° F. (-25° C.) in winter to 96° F (35.5° C.)

TABLE 4. Evaporation rates at approximately 12 inches (0.304 m.) above ground.

Date—*1934*	Open field. Rate of evaporation in cc. per hour	Beech-maple. Rate of evaporation in cc. per hour	Per cent of decrease from open to forest	Weather conditions
June 1 – 4..	.....	0.835	....	very dry
4 – 11..	.....	0.713	....	very dry
11 – 25..	.....	0.524	....	wet
25 – 2..	.....	0.402	....	very wet
July 2 – 9..	.....	0.404	....	very wet
9 – 16..	.....	0.271	....	very wet
August 1 – 6..	0.940	0.350	62.8	very wet
6 – 13..	0.807	0.285	64.7	very wet
13 – 22..	0.740	No record	....	very wet
22 – 27..	0.760	0.270	64.5	very wet
27 – 1..	0.610	0.255	58.2	wet
September 1 – 10..	0.497	0.275	44.7	wet
10 – 17..	0.287	0.152	47.1	wet
17 – 24..	0.520	0.231	35.6	wet
24 – 1..	0.428	0.223	47.9	wet
October 1 – 8..	0.619	0.180	71.0	very wet
8 – 15..	0.481	0.307	36.2 (leaves falling)	—dry
November 24 – 26..	1.137	0.757	33.5 (heavy wind)	—dry
1935				
January 6 – 7..	0.402	0.231	42.6 (ground frozen)	

Average evaporation in forest, June 1 to October 15, — 0.355 cc. per hour per instrument.

in summer; that it may be subject to unseasonable weather, but that for the most part temperatures are within closer limits; that relative humidity is high, for most of the time ranging between 75 and 90 per cent; that precipitation is rather uniform throughout the year, averaging 2.84 inches (7.21 cm.) per month, or 31.62 inches (80.31 cm.) per year for the period of this study; that for 52 per cent of the time when sunshine is possible the sky is overcast; that the force of the wind is ordinarily so tempered by the trunks and branches of the trees in winter, and the addition of their foliage mass in summer, as to make wind disturbances rare throughout its lower levels; that the rate of evaporation is reduced within the forest from 47.1 to 64.7 per cent in summer to from 33 to 42.6 per cent in winter, as compared with the open field at its western edge.

HISTORY OF THE AREA STUDIED

The former Indian occupation of this region is well attested by the collections of flint and stone implements assembled over a period of years by Mr. Ray Parker and Mr. Carl Scheuring whose farms are located close to the area on the southwest. The forest of the area, says Mr. A. C. Keesler, who has lived all his life nearby, has always been a beech woods. The large stumps, well advanced in decay, seen occasionally in the woods, he says represent a cutting made when he was a boy of about 14 (1871), when some large oak, hickory and tulip trees were taken out for lumber. Ap-

parently the particular portion of the area in which our interest centers has suffered little from major disturbances for a long time. There is no evidence of serious fire, either in the place itself, or in the memories of those who, like Mr. Keesler, have a long family tradition associated with the place.

In 1925, 1926, and 1927, the Cleveland Metropolitan Park Board acquired practically all of the 1,201 acres (486.04 hectares) now known as the North Chagrin Reservation, and containing the area under study. Since that time all wild life within the boundaries of the reservation, including both plants and animals, has been under complete protection, no hunting, or other disturbance of natural conditions having been allowed. The policy of the Park Board has been that of conserving natural conditions as far as possible. Picnic grounds and playgrounds are located outside the forested areas. Foot-trails give access to the forest, but there has as yet been little straying from the trails on the part of visitors. No picnic parties are allowed within the woods. One bridle-path crosses the area, and another skirts its western edge. Two uniformed guards regularly patrol the entire reservation to see that park regulations are respected.

CHARACTER OF THE FOREST

Plant Constitution

TREES

In 1932 the writer had recourse to the familiar quadrat method of determining the abundance and distribution of trees and shrubs throughout the area, but as increasing familiarity with the forest was gained it became apparent that the results obtained by the quadrat method were far from satisfactory, and this method was abandoned. Instead, during the winters of 1933-34 and 1934-35, all of the larger trees of the area were measured, and their approximate location charted on individual maps for each species. Measurements were made by tape giving the circumference breast high in inches, and only trees of 30 inches (76.2 cm.) or over in circumference, or slightly over 9.5 inches (24.13 cm.) in diameter, were thus measured and their location charted. Later, a count of all trees of each species was made, section by section, but without the use of quadrats or other measured areas. In this count an effort was made to include all trees down to the 3.5 inch (8.9 cm.) diameter class, the size being judged by eye. While the figures thus obtained are doubtless subject to some error the writer believes them to be substantially in accord with the facts.

On the basis of these counts and maps (Figs. 9 and 10) it appears that there exist 4 major vegetational divisions within the area (Fig. 8) which may be designated as follows:

(1) *The spurs of the eastern edge of the area.* Here occurs a forest mictium including beech, hemlock, red oak, and chestnut, as dominants, together with a relatively large proportion of other species. Chestnut is assigned its position on the basis of large standing trees, though at the present time none are living. It was so recently an important member of this com-

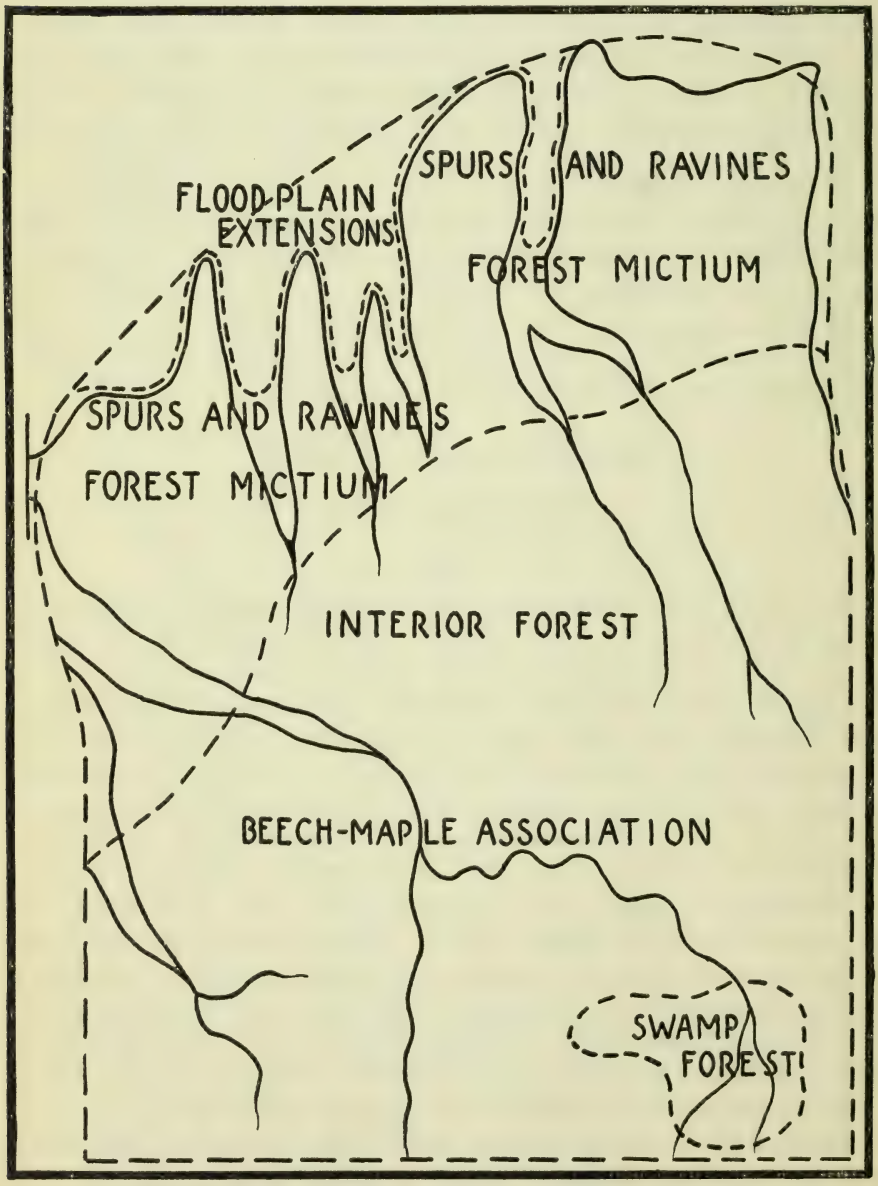

FIG. 8. Major vegetational divisions of the area under study.

munity that it seems desirable here and elsewhere in this study to recognize its former significance.

(2) *The ravines between the spurs.* In the deeper ravines an excess of moisture is always present. Here herbaceous vegetation prolongs its sea-

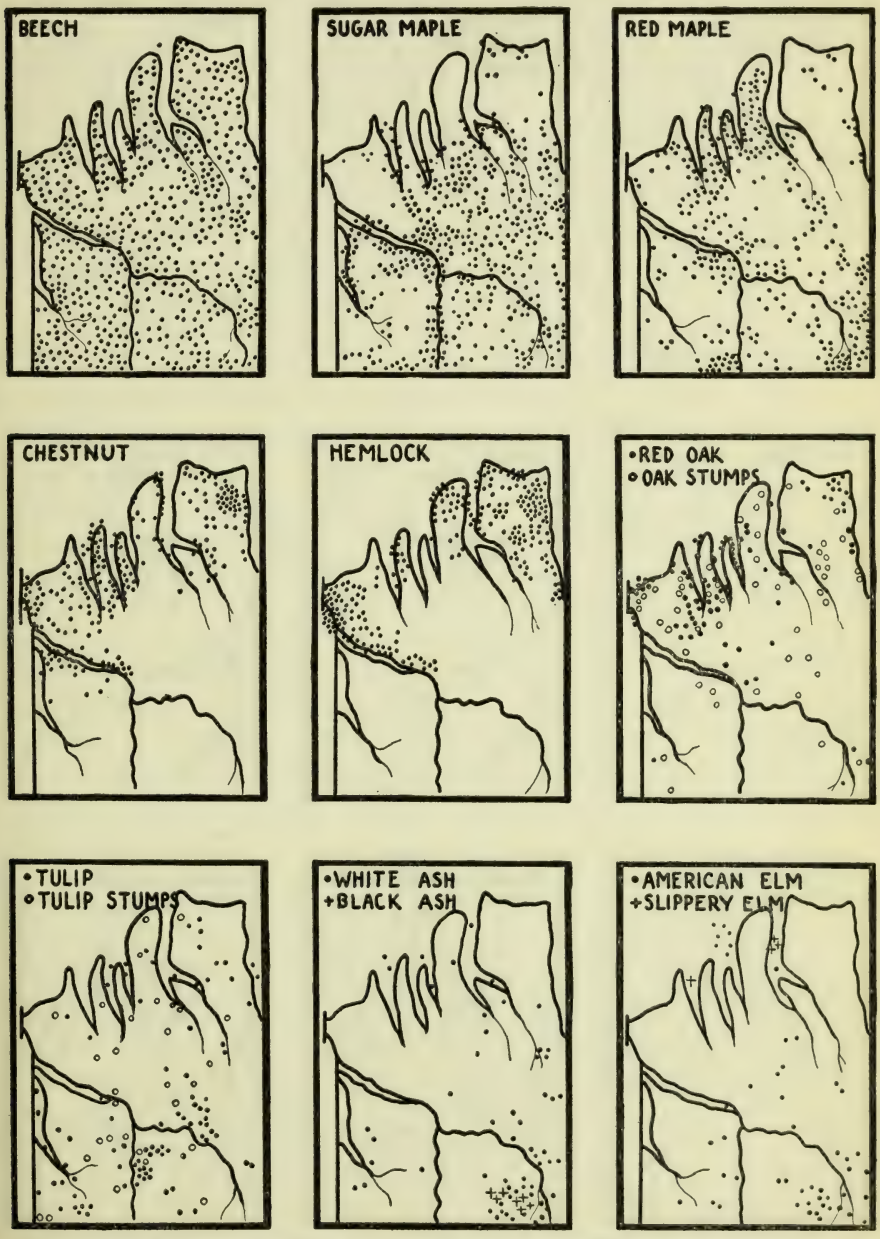

Fig. 9. Distribution of tree species throughout the area under study.

son and grows to larger size than upon the upland. Only here can ferns be said to be well developed. Trees in the ravines often represent bottomland species which have thus extended the flood-plain forest into the area, bringing in some species which otherwise seem out of place. Beech is

FIG. 10. Distribution of tree species throughout the area under study.

absent from the ravines but sugar maple and tulip are present, and in certain places hemlock is found in the ravines. Thus the ravines might be considered as the beginning of a transition stage toward swamp forest or flood-plain conditions.

(3) *The western forest edge, and particularly its southwest corner.* Here, with the exception of some large American elms, the forest is younger than elsewhere, and its character leads one to believe that a portion of it may have served at one time as a "wood-lot" in which only the elms were left undisturbed. The southwest corner has considerable standing water in it during most of the year which accounts for the numbers of American elm, basswood, and red maple here, and the presence of black ash; suggesting the elm-black ash-red maple association described by Sampson (1930) as characteristic of the swamp forest of northeastern Ohio.

(4) *The interior forest.* This includes the larger part of the area under study. The land here is relatively level, and the forest is quite uniformly beech and sugar maple in varying proportions, including a few other associated species as secondary or incidental dominants.

Table 5 shows the abundance and distribution of tree species throughout the four habitats above described. Figure 11, following the method used by Sampson (1930), reduces Table 5 to graphic form. Scientific names in this, and in the following lists of vascular plants, are as given in Gray's Manual of Botany, seventh edition (1908).

Taking the forest as a whole it should be noted that beech composes 51 per cent of it, sugar maple 26.5, red maple 7.2, and hemlock 6.6 per cent. These four species together thus make up 91.4 per cent of the forest. Inasmuch as chestnut has already ceased to be a factor in the community, and, as will be shown later, hemlock and red oak are tending toward exclusion, and tulip and white ash are here secondary succession trees, it appears that the species of greatest importance in this forest are beech, sugar maple, and red maple.

SUBDOMINANT GREEN PLANTS

In this group belong the shrubs, the herbs, the ferns, the climbers, twiners and trailers, and other low-growing plants. As the shrub layer society is very poorly and irregularly developed throughout the entire area, significant differences in the distribution of the plants of this list (Table 6) are largely as between beech-maple and beech-hemlock environments, and their occurrence in either or both of these associations is noted. The order of listing, except in the case of the uncommon to rare species, or unless otherwise noted, is in the order of their abundance.

Spicebush is the most abundant shrub in the area, but it is concentrated largely in two rather moist situations. Maple-leaved viburnum is better distributed than spicebush, but occurs only sparingly. Red-berried elder is

TABLE 5. Species, abundance, and distribution of trees of 3.5 inches in diameter and over.

Species	Beech-maple-association		Beech-hemlock-oak-chestnut mictium		Transition toward swamp forest				Totals	Per cent
					In ravines		Swampy area			
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent		
Beech—*Fagus grandifolia* Ehrh.	1920	52.6	707	43.0	.....	.....	87	28.4	2714	47.2
Sugar Maple—*Acer saccharum* Marsh.	1193	32.7	124	7.5	19	13.0	79	25.6	1415	24.6
Red Maple—*Acer rubrum* L.	227	6.2	113	7.0	10	7.0	31	10.0	381	6.6
Hemlock—*Tsuga canadensis* (L.) Carr.	36	1.0	242	14.9	72	49.0	.....	.....	350	6.1
Chestnut—*Castanea dentata* (Marsh.) Borkh.	36	1.0	235	14.9	.....	.....	.....	.....	271	4.7
Tulip—*Liriodendron tulipifera* L.	110	3.0	14	0.9	6	4.0	2	0.7	132	2.3
Red Oak—*Quercus rubra* L.	8	0.2	78	4.8	5	3.4	3	1.0	94	1.6
White Ash—*Fraxinus americana* L.	25	0.7	.....	.....	7	4.7	29	9.5	61	1.1
American Elm—*Ulmus americana* L.	18	0.5	.....	.....	7	4.7	24	8.0	49	0.9
Hop Hornbeam—*Ostrya virginiana* (Mill.) K. Koch	18	0.5	21	1.2	.....	.....	6	2.0	45	0.8
Basswood—*Tilia americana* L.	7	0.2	.....	.....	6	4.0	25	8.2	38	0.7
Shagbark Hickory—*Carya ovata* (Mill.) K. Koch	20	0.5	4	0.2	.....	.....	7	2.3	31	0.6
Tupelo—*Nyssa sylvatica* Marsh.	5	0.1	21	1.2	.....	.....	.....	.....	26	0.4
Cucumber—*Magnolia acuminata* L.	7	0.2	18	1.1	.....	.....	.....	.....	25	0.4
White Oak—*Quercus alba* L.	7	0.2	16	0.9	.....	.....	1	0.3	24	0.4
Sassafras—*Sassafras varriifolium* (Salisb.) Ktze.	3	0.1	15	0.9	.....	.....	.....	.....	18	0.3
American Hornbeam—*Carpinus caroliniana* Walt.	11	0.3	1	0.0	.....	.....	6	2.0	18	0.3
Flowering Dogwood—*Cornus florida* L.	1	0.0	10	0.6	.....	.....	.....	.....	11	0.2
Wild Black Cherry—*Prunus serotina* Ehrh.	1	0.0	5	0.2	3	2.0	.....	.....	9	0.2
Slippery Elm—*Ulmus fulva* Michx.	.....	.....	.....	.....	6	4.0	.....	.....	6	0.1
Black Ash—*Fraxinus nigra* Marsh.	.....	.....	.....	.....	.....	.....	6	2.0	6	0.1
Black Walnut—*Juglans nigra* L.	.....	.....	2	0.1	2	1.4	.....	.....	4	0.1
Pignut—*Carya glabra* (Mill.) Spach.	.....	.....	4	0.2	.....	.....	.....	.....	4	0.1
Bitternut—*Carya cordiformis* (Wang.) K. Koch.	1	0.0	.....	.....	2	1.4	.....	.....	3	0.2
Shadbush—*Amelanchier canadensis* (L.) Medic.	.....	.....	3	0.2	.....	.....	.....	.....	3	
Butternut—*Juglans cinerea* L.	.....	.....	.....	.....	2	1.4	.....	.....	2	
Black Birch—*Betula lenta* L.	.....	.....	2	0.1	.....	.....	.....	.....	2	
Scarlet Oak—*Quercus coccinea* Muench.	.....	.....	1	0.0	.....	.....	.....	.....	1	
Totals	3654	.....	1638	.....	147	.....	306	.....	5745	100.0

commonly found as a subseral plant where the soil has been disturbed. In most cases the shrubs give the impression of struggling under severe limitations. Their development is usually poor, and they fruit sparingly except in open situations.

In the beech-maple association the herbaceous plants grow luxuriantly, and produce annually a tremendous crop of seeds, fruits, and other food reserves stored in corms, tubers, root-stocks, and other like structures. Spring beauty, spring cress, cut-leaved dentaria, and yellow adder's tongue occur in great numbers on the higher land where there is usually a surplus of standing water in April and May. In certain places the forest floor may aptly be said to be "carpeted" with the blooms of these species. The two trilliums are very abundant in the mid-portion of the area, and grow to large size in the ravines. Dutchman's breeches is common on the higher ground, while squirrel corn seems to prefer the sides of the ravines. Four

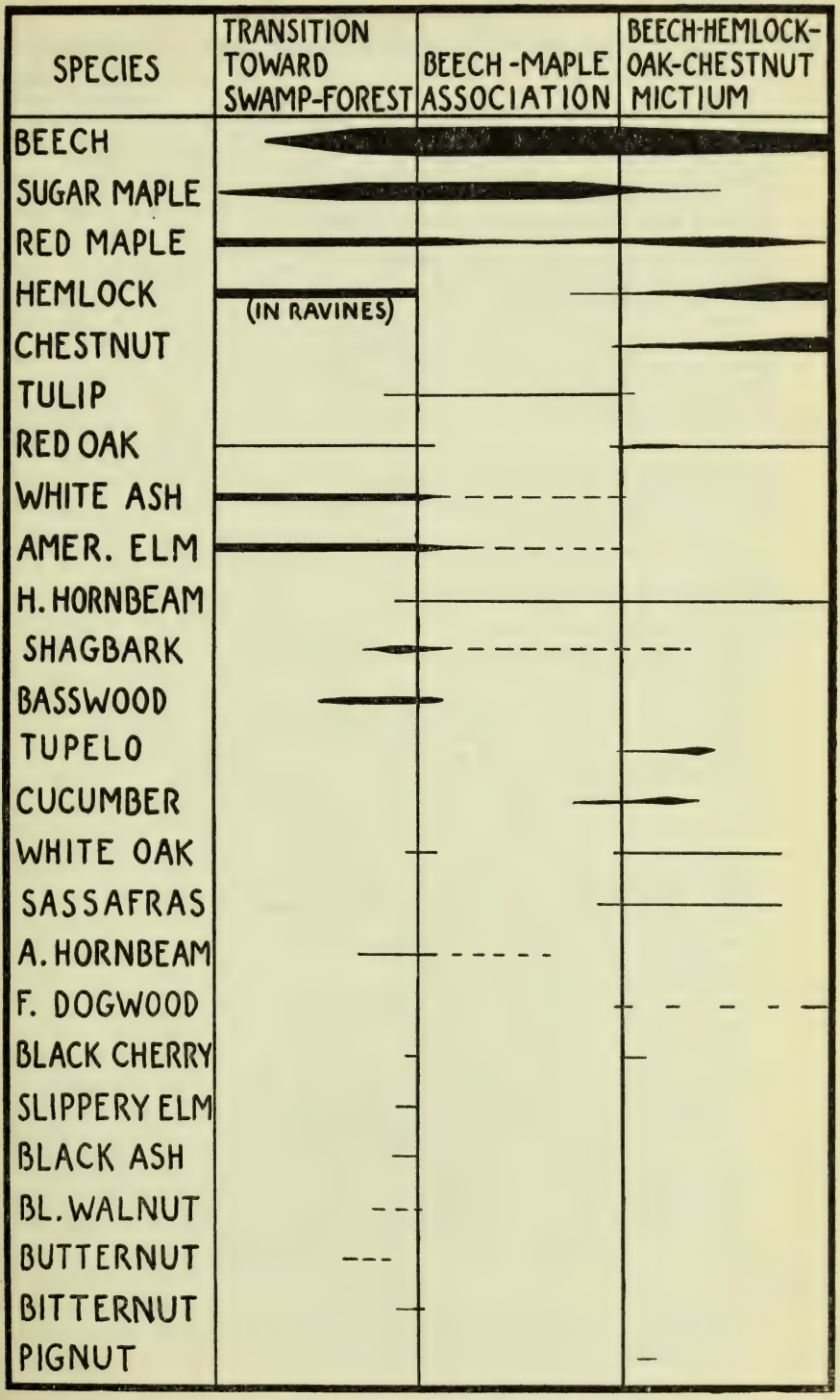

Fig. 11. Distribution and abundance of tree species showing relation to beech-maple association and contiguous forest types.

TABLE 6. Subdominant green plants.

	Beech-maple	Beech-hemlock
1. SHRUBS:		
Spicebush—*Benzoin aestivale* (L.) Nees	*	
Maple-leaved Viburnum—*Viburnum acerifolium* L.	*	*
Red-berried Elder—*Sambucus racemosa* L.	*	
Highbush Blackberry—*Rubus allegheniensis* Porter	*	
Prickly Gooseberry—*Ribes cynosbati* L.	*	*
Purple-flowering Raspberry—*Rubus odoratus* L.	*	
Witch Hazel—*Hamamelis virginiana* L.	*	*
Choke Cherry—*Prunus virginiana* L.	*	
Common Elder—*Sambucus canadensis* L.	*	
Fly Honeysuckle—*Lonicera canadensis* Marsh.		*
Bush Honeysuckle—*Diervilla lonicera* Mill		*
Low Sweet Blueberry—*Vaccinium pennsylvanicum* Lam.		*
Leatherwood—*Dirca palustris* L.		*
2. CLIMBERS, TWINERS, AND TRAILERS:		
Northern Fox Grape—*Vitis labrusca* L.	*	
Trailing Euonymus—*Evonymus obovatus* Nutt.	*	
Virginia Creeper—*Psedera quinquefolia* (L.) Greene	*	*
Poison Ivy—*Rhus toxicodendron* L.	*	
Green Brier—*Smilax rotundifolia* L.	*	
Carrion Flower—*Smilax herbacea* L.	*	
Bittersweet—*Celastrus scandens* L.	*	
3. HERBS AND LOW SHRUBBY PLANTS:		
a. Abundant species (somewhat in the order of their flowering)		
Hepatica—*Hepatica acutiloba* DC	*	
Spring Beauty—*Claytonia virginica* L.	*	
Yellow Adder's Tongue—*Erythronium americanum* Ker.	*	
Round-leaved Violet—*Viola rotundifolia* Michx.	*	
Halberd-leaved Violet—*Viola hastata* Michx.	*	
Wake Robin—*Trillium erectum* L.	*	
Dutchman's Breeches—*Dicentra cucullaria* (L.) Bernh.	*	
Cut-leaved Dentaria—*Dentaria laciniata* Muhl.	*	
Spring Cross—*Cardamine bulbosa* (Schreb.) BSP.	*	
Squirrel Corn—*Dicentra canadensis* (Goldie) Walp.	*	
Rue Anemone—*Anemonella thalictroides* (L.) Spach.	*	
Great White Trillium—*Trillium grandiflorum* (Michx.) Salisb.	*	
Wild Ginger—*Asarum canadense* L.	*	
Sweet Cicely—*Osmorhiza claytoni* (Michx.) Clarke	*	
Toothwort—*Dentaria diphylla* Michx.	*	
Oakesia—*Oakesia sessilifolia* (L.) Wats.	*	
Downy Yellow Violet—*Viola pubescens* Ait.	*	
Smooth Yellow Violet—*Viola scabriuscula* Schwein.	*	
Canada Violet—*Viola canadensis* L.	*	
Dwarf Ginseng—*Panax trifolium* L.	*	
Foam Flower—*Tiarella cordifolia* L.	*	
Solomon's Seal—*Polygonatum biflorum* (Walt.) Ell.	*	
Canada Mayflower—*Maianthemum canadense* Desf.		*
Jack-in-the-Pulpit—*Arisaema triphyllum* (L.) Schott.	*	
May Apple—*Podophyllum peltatum* L.	*	
False Spikenard—*Smilicina racemosa* (L.) Desf.	*	
Pale Jewelweed—*Impatiens pallida* Nutt.	*	
Spotted Jewelweed—*Impatiens biflora* Walt.	*	
Pokeweed—*Phytolacca decandra* L.	*	
b. COMMON SPECIES:		
Blue Cohosh—*Caulophyllum thalictroides* (L.) Michx.	*	
Large-flowered Bellwort—*Uvularia grandiflora* Sm.	*	
Swamp Buttercup—*Ranunculus septentrionalis* Poir.	*	

Table 6. Continued

	Beech-maple	Beech-hemlock
Yellow Rocket—*Barbarea vulgaris* R. Br.	*	
Common Violet—*Viola papilionacea* Pursh	*	
Indian Cucumber—*Medeola virginiana* L.	*	*
Wild Sarsaparilla—*Aralia nudicaulis* L.	*	
Twisted Stalk—*Streptopus amplexifolius* (L.) DC	*	
Partridgeberry—*Mitchella repens* L.		*
White Baneberry—*Actaea alba* (L.) Mill.	*	
Wild Blue Phlox—*Phlox divaricata* L.	*	
Wild Geranium—*Geranium maculatum* L.	*	
Northern Bedstraw—*Galium boreale* L.	*	
Black Snakeroot—*Cimicifuga racemosa* (L.) Nutt.	*	
Wintergreen—*Gaultheria procumbens* L.		*
Richweed—*Pilea pumila* (L.) Gray	*	
c. Uncommon to Rare Species:		
Harbinger of Spring—*Erigenia bulbosa* (Michx.) Nutt.	*	
Bloodroot—*Sanguinaria canadensis* L.	*	
Trailing Arbutus—*Epigaea repens* L.		*
Perfoliate Bellwort—*Uvularia perfoliata* L.	*	
Early Meadow Rue—*Thalictrum dioicum*	*	
Wood Anemone—*Anemone quinquefolia* L.	*	
Wood Betony—*Pedicularis canadensis* L.	*	
Sweet White Violet—*Viola blanda* Willd.	*	
Great-spurred Violet—*Viola rostrata* Pursh.	*	
Wood Sorrel—*Oxalis corniculata* L.	*	
Bishop's Cap—*Mitella diphylla* L.	*	
Golden Seal—*Hydrastis canadensis* L.	*	
Virginia Waterleaf—*Hydrophyllum virginianum* L.	*	
Pink Lady's Slipper—*Cypropedium acaule* Ait.		*
Agrimony—*Agrimoria striata* Michx.	*	
Monkey Flower—*Mimulus ringens* L.	*	
Round-leaved Orchid—*Habenaria orbiculata* (Pursh.)	*	
Great Lobelia—*Lobelia siphilitica* L.	*	
Wild Leek—*Allium tricoccum* Ait.	*	
Ginseng—*Panax quinquefolium* L.	*	
Indian Tobacco—*Lobelia inflata* L.	*	
Cardinal Flower—*Lobelia cardinalis* L.	*	
Nodding Pogonia—*Pogonia trianthophora* (Sw.) BSP	*	
Spikenard—*Aralia racemosa* L.	*	
4. Ferns:		
Christmas Fern—*Polystichum acrostichoides* (Michx.) Schot.	*	*
Spinulose Wood Fern—*Asplenium spinulosum intermedium* D. C. Eaton	*	*
Silvery Spleenwort—*Asplenium acrostichoides* Sw.	*	
New York Fern—*Aspidium noveboracense* (L.) Sw.	*	*
Marginal Shield Fern—*Aspidium marginale* (L.) Sw.	*	*
Rattlesnake Fern—*Botrychium virginianum* (L.) Sw.	*	
Broad Beech Fern—*Phegopteris haxagonoptera* (Michx) Fee.	*	
Maidenhair Fern—*Adiantum pedatum* L.	*	*
Long Beech Fern—*Phegopteris polypodioides* Fee.	*	
Sensitive Fern—*Onoclea sensibilis* L.	*	
Ternate Grape Fern—*Botrychium ternatum intermedium* D. C. Eaton	*	
Interrupted Fern—*Osmunda claytoniana* L.	*	
Narrow-leaved Spleenwort—*Asplenium angustifolium* Michx.	*	(in ravines)
Hay-scented Fern—*Dicksonia punctilobula* (Michx.) Gray	*	

TABLE 6. Continued

	Beech-maple	Beech-hemlock
5. MOSSES:		
Amblystegium serpens (L.) B & S	*	*
Thuidium delicatulum (L.) Mitt.	*	
Hypnum haldanianum Grev.	*	
Hypnum reptile Mx.	*	
Funaria hygrometricia (L.) Sibth.	*	
Leucobryum glaucum (L.) Schimp.		*
Mnium cuspidatum (L.) Leyss.	*	*
Dicranella heteronalla (L.) Schimp.	*	*
Catharinea undulata (L.) W & M.	*	
Fissidens taxifolius (L.) Hedw.	*	
6. MISCELLANEOUS:		
Sedge—*Carex plantaginea* Lam.	*	
Club Moss—*Lycopodium lucidulum* Michx.		*
Lichen—*Cladonia fimbriata* (L.) Hoffm. Deutsch.	*	*
Liverwort—*Marchantia polymorpha* (L.)	*	
Alga—*Microspora amoena* (Kütz.) Lagerh.	*	
Alga—*Protococcus* sp. (on beech trunks)	*	*

species of yellow violets bloom abundantly. Hepatica grows in masses in moist places along the water-courses and on the edges of the ravines. False spikenard, solomon's seal, and twisted stalk are quite generally distributed. Wild ginger and May apple cover the ground with their characteristic leaves in certain locations. Jack-in-the-pulpit and blue cohosh are well distributed. The tiny dwarf ginseng, in its season, shows its small puff-balls of white bloom throughout the forest. The evergreen leaves of foam flower are common in the wetter places, and over the edges of the ravines. Those curious plants, beech drops, and squaw root, are common, the former more so than the latter; and the pale Indian pipe is found frequently. The late-comers, white baneberry and black snake-root, are common. Jewelweed and pokeweed grow luxuriantly in certain places.

In great contrast to this rich development of herbaceous growth beneath the beeches and maples is the thinly spread ground cover beneath the hemlocks. The common herbaceous plant of the beech-hemlock association is the Canada mayflower. In certain locations it covers the ground, but it is the only plant of which this can be said. In this environment partridge berry and wintergreen appear frequently. Apart from these there is very little. It is in this habitat that a few plants of pink lady's slipper and trailing arbutus occur.

This difference in herbaceous growth was studied in Indiana by Daubenmire (1930), who concluded that, of the factors studied (light, evaporation rate, soil acidity, soil moisture), soil moisture conditions exerted the most inhibitive influence on vegetational development under hemlock, while the

greater acidity of the surface soil is probably a contributing factor in the inhibition of forest floor herbs.

In no place in the area do ferns grow in abundance. Small societies of New York fern occur sparingly on the higher land and on some of the spurs. Christmas fern, marginal shield fern, and spinulose wood fern are all well distributed as individual plants, reaching their best development along the edges of the gullies and ravines. Rattlesnake fern is well distributed on the higher land. Other ferns on the list occur only occasionally. In general, while most of these ferns may be found in both associations, they are more abundant in beech-maple than in beech-hemlock environment, and are best developed in the ravines and along their sides. There is little poison ivy in the area, and such as there is, is confined to the beech-maple association on higher ground. In places Virginia creeper grows as ground cover, and in a few places it ascends the trees. In certain locations in the beech-maple association trailing euonymus forms dense mats as ground cover.

The vine *par excellence* in the area is the northern fox grape. It may form tangles in the tops of large standing trees, or hang in a dense "curtain" from lofty supports, or create tangles on the ground when the original supporting trees have broken down, letting the whole mass down to ground level. In the latter case a great opening is made in the forest canopy. Secondary succession after grapes is obscure, as nothing grows beneath the grapes in this condition.

Neither mosses nor lichens are particularly abundant in the area. Probably the creeping hypnum, *Amblystegium serpens,* growing on logs and stones, is the most common moss in the beech-maple association, and the cushion moss, *Leucobryum glaucum,* is the most common in the beech-hemlock association. The sedge, *Carex plantaginea,* is one of the well distributed plants of the beech-maple association.

SAPROPHYTES AND PARASITES

Saprophytic and parasitic plants in the area fall in two main groups—flowering plants and fungi. They are listed in Table 7. Although the fungi listed represent four seasons of observation it is realized that the list is far from complete, as new species are constantly being added. However, it may be assumed that those species that are of greatest importance in the area, because of their abundance, regularity of appearance, or wide distribution, are noted herein.

Doubtless because of the long time during which the natural processes of decay have been at work in the forest under study, the number of species, and the abundance of certain fungi, is great. In fact, Mr. Henry C. Beardslee, an authority on Ohio fungi, gives it as his opinion that from 1,200 to

TABLE 7. Saprophytic and parasitic plants.

1. Flowering plants.
   - Beech Drops—*Epifagus virginiana* (L.) Bart. (beech-maple association)
   - Squaw Root—*Conopholis americana* (L.f.) Wallr. (beech-hemlock association)
   - Indian Pipe—*Monotropa uniflora* L. (beech-maple association)
2. Fungi.
   - A. Abundant fungi (in order of abundance)
     - a. Woody brackets
       - *Polyporus applanatus* Fr.
       - *Polyporus resinosus* (Fr.) Schrader.
       - *Polyporus gilvus* (Fr.) Schw.
     - b. Leathery brackets
       - *Polyporus versicolor* Fr.
       - *Polystictus pergamenus* Fr.
       - *Stereum spadiceum* Fr.
       - *Polyporus hirsutus* Schw.
     - c. Gilled mushrooms
       - *Collybia radicata* Rehl.
       - *Armillaria mellea* Vahl.
       - *Pleurotus ostreatus* Jacq.
       - *Hypholoma sublateritium* Schaeff.
       - *Hypholoma perplexum* Pk.
       - *Clitopilus abortivus* B & C.
       - *Mycena Leajana* Berk.
       - *Coprinus atramentarius* (Bull.) Fr.
       - *Collybia platyphylla* Fr.
     - d. Puff-balls
       - *Lycoperdon pyroforme* Schaeff.
       - *Scleroderma aurantium* (Vaill.) Pers.
     - e. Gelatinous fungi
       - *Tremella mesenterica* Retz.
       - *Exidia glandulosa* (Bull.) Fr.
     - f. Chestnut blight
       - *Endothia parasitica* (Murr.) Ander. and Ander.
   - B. Common fungi (not in order of abundance)
     - a. Woody and leathery polypores
       - *Polyporus lucidus* (Leys.) Fr.
       - *Polyporus sulphureus* (Bull.) Fr.
       - *Fomes fomentarius* Fr.
       - *Polyporus brumalis* (Pers.) Fr.
     - b. Gilled mushrooms
       - *Amanita verna* Fr.
       - *Amanitopsis vaginata* Roze.
       - *Claudopus nidulans* (Pers.) Pk.
       - *Clitocybe illudens* Schw.
       - *Clitocybe infundibuliformis* Schaeff.
       - *Collybia velutipes* Curt.
       - *Collybia strictipes* Pk.
       - *Coprinus micaceous* (Bull.) Fr.
       - *Crepidotus versutus* Pk.
       - *Gomphidius rhodoxanthus* Schw.
       - *Hypholoma appendiculatum* Bull.
       - *Lepiota procera* Scop.
       - *Marasmius rotula* Fr.
       - *Marasmius siccus* (Schw.) Fr.
       - *Mycena haemotopoda* Pers.
       - *Mycena galericulata* Scop.
       - *Omphalia campanella* Batsch.
       - *Pholiota adiposa* Fr.
       - *Pleurotus sapidus* Kalchb.
       - *Pleurotus serotinoides* Fr.

Pluteus cervinus Schaeff.
Russula emetica Fr.
Russula fragilis Fr.
Russula mariae Pk.
Strobilomyces strobilaceus Berk.

c. Boletaceae
Boletus felleus Bull.
Boletus edulis Bull.
Boletus peckii Frost.
Boletinus porosus (Berk.) Pk.
Fistulina hepatica Fr.

d. Puff-balls
Geaster triplex Jungh.
Lycoperdon gemmatum Batsch.

e. Coral fungi
Clavaria flava Schaeff.
Clavaria cinerea Bull.

f. Spore-sac fungi (Ascomycetes)
Peziza coccinea Jacq.

C. Uncommon to rare fungi (not in order of abundance)

a. Gilled mushrooms

Agaricus sylvaticus Schaeff.
Agaricus sylvicola Vitt.
Amanita flavorubescens Atk.
Amanita muscaria L.
Amanita rubescens Fr.
Amanita solitaria Bull.
Armillaria amianthina Fr.
Cantherellus aurantiacus Fr.
Cantherellus cibarius Fr.
Cantherellus rosellus Pk.
Cantherellus umbonatus Fr.
Clitocybe adirondackensis Pk.
Clitocybe albissima Pk.
Clitocybe candida Bres.
Clitocybe clavipes Pers.
Clitocybe cyathiforme Fr.
Clitocybe fragrans Sow.
Clitocybe laccata Scop.
Clitocybe multiceps Pk.
Clitocybe multiformis Pk.
Clitocybe nebularis Batsch.
Clitocybe ochropurpurea Berk.
Clitocybe odora Bull.
Clitocybe pieceina Pk.
Clitocybe subcyathiforme Pk.
Clitopolis noveboracense Pk.
Clitopolis orchella Fr.
Collybia butyracea Fr.
Collybia confluens Pers.
Collybia colorea Pk.
Collybia dryophila Fr.
Collybia tuberosa Fr.
Coprinus comatus Fr.
Cortinarius alboviolaceus Fr.
Cortinarius distans Pk.
Cortinarius duracinus Fr.
Crepidotus applanatus Fr.
Crepidotus fulvotomentosus Pk.
Crepidotus malachius B & C.
Darcomyces deliquescens (Bull.) Duby.
Entoloma jubatum Pk.
Entoloma niderosum Fr.
Entoloma rhodopolium Fr.
Entoloma strictus Pk.
Flammula flavida Fr.
Flammula lenta Fr.
Flammula spumosa Fr.
Hygrophorus cantherellus Schw.
Hygrophorus ceraceus Fr.
Hygrophorus chlorophanus Fr.
Hygrophorus fulgineus Frost.
Hygrophorus miniatus Fr.
Hygrophorus pratensis Fr.
Hygrophorus coccineus Schaeff.
Hygrophorus conicus Fr.
Hypholoma echinoceps Atk.
Hypholoma hydrophilum Fr.
Hypholoma lachrymabundum Fr.
Hypholoma rugocephalium Atk.
Inocybe radiata Pk.
Lactarius chrysorheus Fr.
Lactarius cinereus Pk.
Lactarius fuliginosus Fr.
Lactarius helvus Fr.
Lactarius hysginus Fr.
Lactarius piperatus Scop.
Lactarius subdulcis Fr.
Lactarius trivialis Fr.
Lactarius vietus Fr.
Lactarius volemus Fr.
Lentinus ursinus Fr.
Lenzites betulina Fr.
Lepiota acutaesquamosa Fr.
Lepiota clypeolaria Fr.
Lepiota cristata Fr.
Lepiota metulaespora B & Br.
Lepiota naucina Fr.
Leptonia asprella Fr.
Leptonia formosa Fr.
Marasmius delectans Morg.

Marasmius elongatipes Pk.
Marasmius spongiosus B & C.
Mycena albolutea Pk.
Mycena cohaerens Fr.
Mycena minutula Pk.
Mycena polygramma Bull.
Mycena pura Fr.
Nolanea pascua Fr.
Panus strigosus B & C.
Panus stypticus Fr.
Paxillus lepista Fr.
Pholiota erebia Fr.
Pholiota mutabilia Fr.
Pholiota spectabilis Fr.
Pholiota squarrosoides Pk.
Pleurotus petaloides Bull.
Pluteolus reticulatus Fr.
Pluteus granularis Pk.
Russula alutacea Fr.
Russula lepida Fr.
Russula pusilla Pk.
Russula sordida Pk.
Russula uncialis Pk.
Russula vinosa Lindb.
Tricholoma laterarium Pk.
Volvaria bombycina Schaeff.

Marasmius oreades Fr.
Marasmius velutipes B & C.
Mycena alkalina Fr.
Mycena filopes Fr.
Mycena peliantha Fr.
Mycena pulcherrima Pk.
Nectria cinnibarina (Tode.) Fr.
Omphalia fibula Fr.
Panus rudis Fr.
Panus torulosis Fr.
Paxillus panuoides Fr.
Pholiota marginata Batsch.
Pholiota praecox Pers.
Pholiota squarrosa Müll.
Pleurotus corticatus Fr.
Pleurotus ulmarius Fr.
Pluteus admirabilis Pk.
Pluteus longistriatus Pk.
Russula foetans Fr.
Russula lutea (Huds.) Fr.
Russula purpurina Quel. & Sch.
Russula rubescens Beards.
Russula sanguinea Fr.
Stropharia squamosa (Pers.) Fr.
Tricholoma personatum Fr.

b. Boleti

Boletus alutaceus Morg.
Boletus chrysenteron Fr.
Boletus scaber Fr.

Boletus castaneus Bull.
Boletus diochrous Ellis.
Boletus subtomentosus Fr.

c. Puff-balls

Calvatia cyathiformis Bosc.
Lycoperdon echinatum Pers.
Cyathus striatus Willd.

Geaster hygrometricius Pers.
Lycoperdon subincarnatum Pk.

d. Spore-sac fungi (Ascomycetes)

Bulgaria inquinans Fr.
Gyromitra esculenta Fr.
Morchella esculenta Pers.
Peziza badia Pers.
Peziza scutellata

Geoglossum
Helvella crispa Fr.
Peziza aurantia Pers.
Peziza odorata Pk.
Xylaria polymorpha Pers.

e. Polypores

Daedalia ambigua Berk.
Daedalia confragosa Boton.
Merulius lachrymans (Jacq.) Fr.
Polyporus frondosus Fr.
Polyporus picipes Fr.
Polyporus squamosus Fr.

Favolus canadensis Klotsch.
Polyporus cinnibarinus Jacq.
Polyporus galactinus Berk.
Polyporus radicatus Schw.
Polyporus umbellatus Fr.

f. Other species

Clavaria amethystina Bull.
Clavaria inequalis Fl. Dan.
Clavaria muscoides Fr.

Clavaria aurea Schaeff.
Clavaria mucida Pers.
Clavaria vermicularis Scop.

Hydnum caput-ursi Fr.
Hydnum erinaceus Bull.
Hydnum septentrionale Fr.

Hydnum coralloides Scop.
Hydnum repandum (L.) Fr.

Tremella albida Huds.
Tremellodon gelatinosum Pers.
Hyroneola auricula-judae (L.) Berk.

Tremella lutescens Pers.
Tremalitelia nucleata (Seb.) Rea.

Craterellus cantherellus Schw.
Stereum sericium Schw.
Phallus ravenelii B & C.

Mutinus elegans (Mont.) Ed. Fischer.

1,500 species of the larger fungi should eventually be listed in such a forest as this. Of the woody sporophores that are persistent as brackets throughout the year, those of *Polyporus applanatus* are by far the most abundant. Usually these are the first of the brackets to appear upon newly fallen tree trunks, and often appear upon living trees. Even in such a case, however, they are probably growing on dead wood (Von Schrenk and Spaulding 1909). This fungus has been noted upon the decaying logs of practically all of the species of trees within the area.

Of the leathery polypores, *Polyporus versicolor* is in evidence everywhere, and usually its banded ruffles are the first fungus growth to appear upon fallen logs or branches of whatever species. *Stereum spadiceum* and *Polystictus pergamenus* may frequently be found in close competition with *Polyporus versicolor*. The service of these fungi and a few other closely related species in the forest under study in helping return to the soil the mass of woody plant débris which otherwise would continually accumulate can scarcely be overestimated. Bray (1915) points out that if it were not for some such disintegrating force at work in the forest, the surface of the ground would soon become clogged to such an extent as to make further plant growth impossible. Considering the number of species of fungi recorded at North Chagrin, and the great abundance of their sporophores at certain seasons, it is apparent that the humus must be thoroughly permeated with fungus mycelium, and that the fallen leaves, branches, and tree trunks are all "hot beds" of fungus activity.

The presence and the fruiting bodies of slime moulds (Myxomycetes) have been frequently noted, but no attempt has as yet been made to study their distribution or significance.

Dynamics of Succession

Throughout the area the presence of old stumps, logs, and standing dead trees indicates something of the character of the forest of the recent past. Despite the passage of more than 60 years it is possible to recognize three species of trees represented by the stumps said to have been cut in 1871. These are oak (probably red oak, as this is the present most abundant species of oak), tulip, and chestnut. The species maps of tulip and red oak (Fig. 10) show both the living trees and the old stumps. It is apparent that red oak was formerly a constituent of the interior forest in much greater numbers than now. The 50 oak stumps that were measured showed an average diameter, without bark of sapwood, of 38.2 inches (97.03 cm.) at approximately 3 feet (91.44 cm.) from the ground. The average diameter of the 50 largest living red oaks is 30.2 inches (76.7 cm.) Apparently the stumps represent a considerably more mature stand than do the present trees.

There are 32 stumps of tulip recognizable at the present time. Measurements of these show an average diameter of 32.8 inches (83.31 cm.) without bark, at approximately 3 feet from the ground. The largest 32 living tulips show an average diameter of 29.6 inches (75.18 cm.), a size not greatly below that of the old stumps. A study of the species map (Fig. 10) indicates that the position of tulip in the community has changed little, if any, in the past 60 years.

The chestnut stumps cut in other years are few in number and are all located in present chestnut territory, indicating no recent movement of chestnut.

On the forest floor it is possible to recognize logs of beech, sugar maple, sassafras, tulip, tupelo,[2] cucumber, and hemlock. Of these, sassafras, cucumber, and hemlock are the only species that, from the position of the logs in the area, indicate a change in distribution as compared with the present. Of the standing dead trees, only cucumber and hemlock exhibit change of distribution. Sassafras and cucumber are apparently in process of being eliminated from the interior forest, as both formerly occurred there but are now practically limited to the spurs or their immediate vicinity (Fig. 10). Hemlock appears to be rapidly decreasing in numbers. Figure 12 shows the location of 85 standing dead hemlocks measuring from 10 inches (25.4 cm.) to 28.6 inches (73.2 cm.) in diameter. The discovery of the larvae of the flat-headed hemlock borer (*Melanophila fulvoguttata* Harr.) beneath the bark of many trees leads to the supposition that the activities of this insect is the immediate cause of the death of these otherwise apparently sound hemlocks. A comparison of Figure 12 with Figure 9 will show that these trees are in the heart of the present hemlock areas.

The rate of reproduction may have a large bearing upon the matter of stability or change in status of the forest constituents. The seeding of both beech and sugar maple is periodically abundant, but beech seedlings do not survive as well as those of sugar maple in the early stages of their development. In one area of approximately 25 feet (7.62 m.) square, 12 beech trees of from 2 to 4 seasons growth were counted, while the number of sugar maples of the same age in the same area was estimated to be in the neighborhood of 3,000—a proportion of 1 beech to 250 sugar maples. Yet the high mortality of young sugar maple saplings later seems to more than make up for this great difference in the early years of development. At present the seeding of both of these trees seems to be adequate to the needs of replacement of the species to make good the annual losses from the ranks of the old trees, and beech has the additional advantage of sending up suckers from the roots.

[2] Wherever "tupelo" is used in this paper the author refers to the common black gum, *Nyssa sylvatica* Marsh., and not *Nyssa aquatica* Marsh. which is most commonly called "tupelo" throughout the Southeast.—Ed.

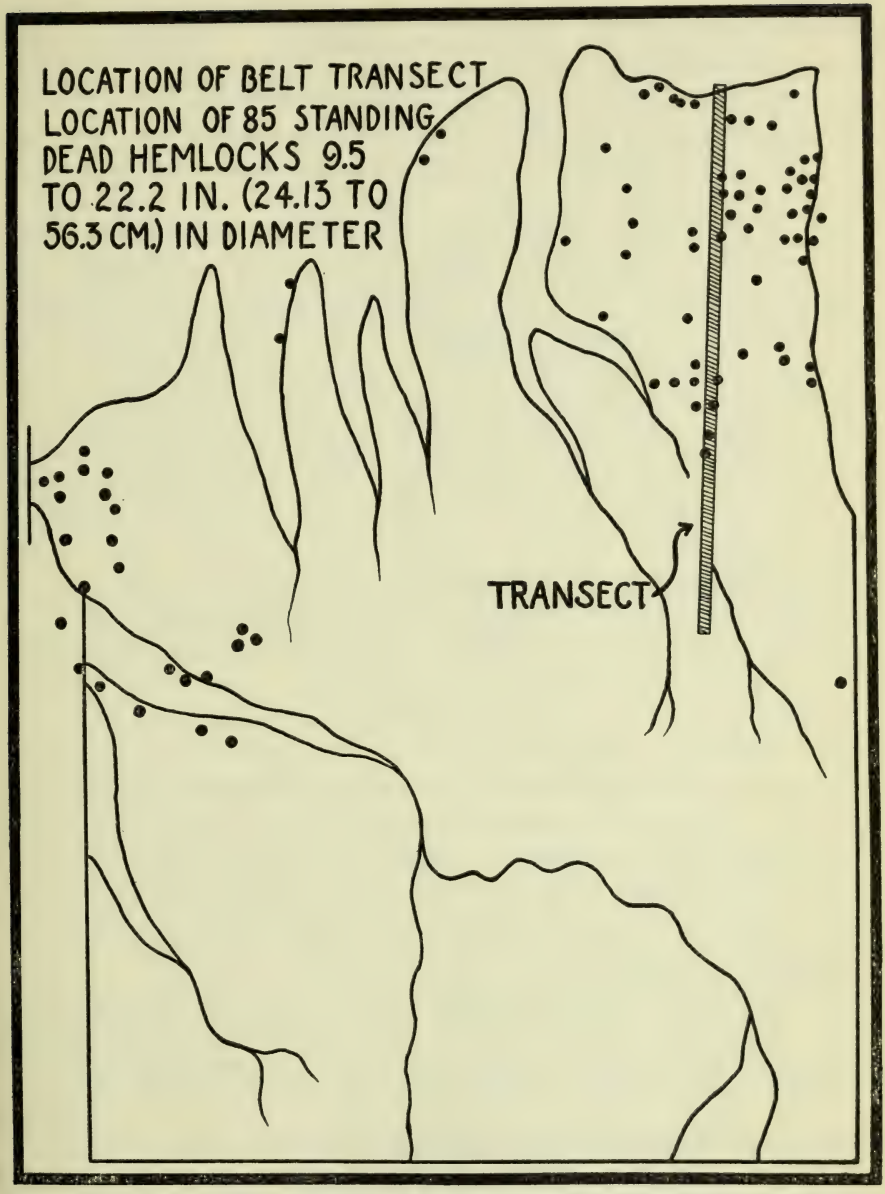

Fig. 12. Location of standing dead hemlocks. Location of belt transect.

According to Illick and Frantz (1928) under favorable conditions in Pennsylvania dense stands of beech will develop from root suckers alone.

While the seeding of red maple is at times very abundant, germination is poor, and seedlings and saplings do not survive in competition with those of beech and sugar maple.

The hemlocks of the area at times bear abundant crops of seeds, but germination has long been practically at a standstill. Apparently because of more favorable moisture conditions there was a fair amount of germination of hemlock seeds in 1935, but it remains to be seen whether or not a succeeding dry summer may wipe them out. In the hemlock areas it is quite noticeable that the dead leaves of beech and maple make up the bulk of the litter under the trees.

Both tulip and white ash bear seeds regularly and abundantly, and their seeds germinate well, but neither species long survives in competition with seedlings of beech and sugar maple. It is only in those places where sunlight has been let in, usually because of the fall of a large tree, that ash and tulip are able to raise their heads and make a place for themselves in the forest community. Under such conditions they make rapid growth.

Red oak and white oak often bear large quantities of acorns. Red oak in particular often so covers the ground with its seeds that they blanket everything else. Yet there are practically no oak seedlings or saplings of any kind in the forest.

The few hickories in the area produce good crops of nuts, yet there are no seedling or sapling hickories to be found away from the forest edge.

Cucumber and tupelo are regular seeders, and a considerable number of very young trees of these species are to be found in the neighborhood of the old trees. In addition, both of these species will sucker from exposed roots or the bases of stumps.

In order to study more definitely the relative significance of beech, sugar maple, and hemlock in the climax community, a belt transect was charted from a point in the beech-maple association on the higher ground, almost directly east to the edge of the bluff, thus traversing the entire width of the most extensive beech-hemlock territory in the area. Reference to Figure 12 will show its location.

The belt was 10 meters (32.8 feet) in width, and extended for a total distance of 360 meters (1181.1 feet). It was subdivided into 45 quadrats, each 10 by 8 meters (32.8 by 26.2 feet). The approximate position of all trees 2.5 cm (1 inch) or over in circumference was charted in each of these quadrats, and the trees measured breast high by tape. This chart is shown in Figure 13. A study of it reveals the following facts:

1. Beech is represented by large trees throughout the transect—32 of these ranging from 24 cm. (9.4 inches) to 80 cm. (31.5 inches) in diameter.

2. Sugar maple decreases in size as the hemlock area is approached, until it is represented only by saplings, and then soon drops out altogether.

3. Many decaying logs of hemlock on the ground are encountered before the present beech-hemlock association is reached. This condition persists well

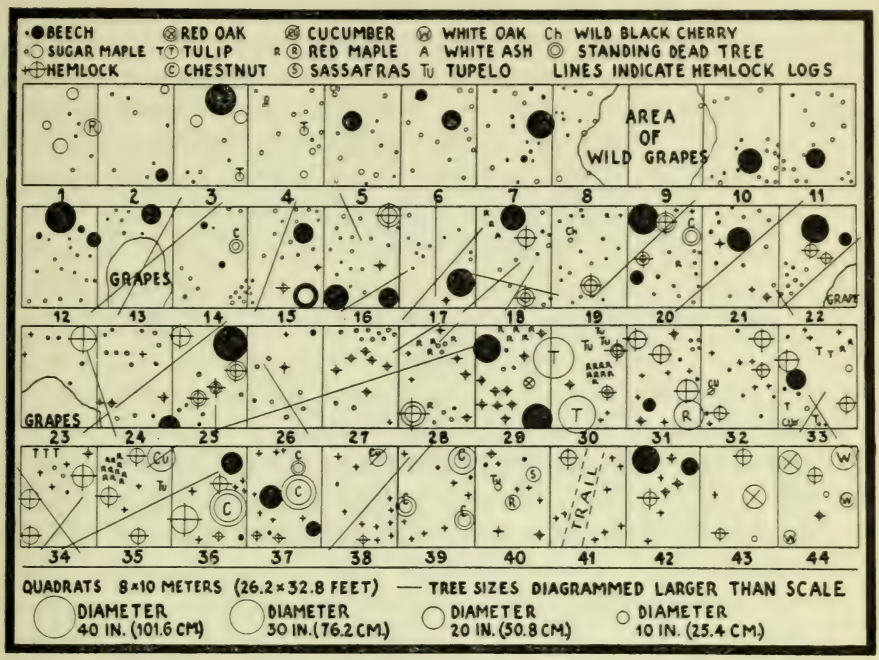

Fig. 13. Belt transect.

into the present beech-hemlock territory, but becomes less marked as the best hemlock development is reached. Practically all down timber in the transect is hemlock.

4. Reproduction of both beech and sugar maple, as represented by saplings and young growth in the transect is good. Reproduction of hemlock is poor—almost negligible.

5. The presence of large tulip, tupelo, cucumber, and chestnut is noted—the tulip outside the beech-hemlock territory, the other species associated with the hemlocks. The presence of oaks is noted as the edge of the bluff is reached.

6. Red maple appears as a rather constant but not important element in the transect.

A consideration of the age of the community under study may shed some additional light on the dynamics of succession. Table 8 shows the distribution of the most important tree species through certain size classes. It will be noted that all of the species here shown exhibit a peak of numbers in what might be called the middle size classes, with diminishing numbers toward both larger and smaller sizes. Although not shown in this table it is a fact that both beech and sugar maple show much larger numbers in smaller sizes than those included in Table 8. This is shown by the counts

recorded in Table 5, as well as by general observation. Sugar maple especially, in certain locations, has produced a tremendous number of saplings of from an inch to three inches in diameter. These dense stands of young maples are not of general distribution. They probably represent the heavy seeding of certain old trees under especially favorable circumstances in former years. Mortality among such young trees must be very great when a certain critical point in their development is reached, as Mr. Percy Parker, who has lived many years in the neighborhood, tells the writer that certain areas that are now practically clear of understory trees used to be densely crowded with sugar maple saplings when he used to hunt rabbits in these woods as a boy. In this connection it is interesting to note that one of the very areas thus pointed out by Mr. Parker and now devoid of young saplings, was recently covered (1935) with hundreds of thousands of sugar maple seedlings, standing so closely together as to provide a ground cover of continuous green throughout the summer, where in the previous years of this study the aspect had invariably been that of the almost unbroken brown of dead leaves.

It is of interest to note (Table 8) the decrease in numbers of individuals as the older trees (larger sizes) are considered. They seem to be approaching a limit of size that is rather definitely set.

TABLE 8. Numbers of trees in different size classes.

	DIAMETERS							
Inches.....	9.5 - 12	12 - 15	15 - 18	18 - 21	21 - 24	24 - 27	27 - 30	30 - 33
Centimeters.....	24.1 - 30.4	30.4 - 38.1	38.1 - 45.7	45.7 - 53.3	53.3 - 60.9	60.9 - 68.5	68.5 - 76.2	76.2 - 83.8
Beech.....	17	71	132	112	162	81	63	10
Sugar Maple.....	127	173	105	78	61	31	10	2
Red Maple.....	56	93	83	48	29	9	4	3
Hemlock.....	79	103	73	39	26	2	2	0
Chestnut.....	13	38	44	55	48	19	24	15
Tulip.....	29	19	4	1	6	5	4	5
White Ash.....	10	12	14	4	3	6	3	1
Red Oak.....	5	7	9	14	12	20	10	10

	DIAMETERS							
Inches.....	33-36	36 - 39	39 - 42	42- 45	45 - 48	48 - 51	.....	63.2
Centimeters....	83.8-91.4	91.4 - 99.0	99.0-106.6	106.6 - 114.3	114.3 - 121.9	121.9 - 129.5	.....	160.5
Beech.....	9	4	3	1	..	..	..	..
Sugar Maple.....	1	1	0	1	..	..	..	..
Red Maple.....	3	2	1	1	..	..	..	..
Hemlock.....	0	0	0	0	..	..	..	..
Chestnut.....	6	3	2	2	..	..	..	..
Tulip.....	4	3	2	1	..	..	..	..
White Ash.....	2	0	0	0	..	..	..	..
Red Oak.....	3	0	2	0	1	1	..	1

To this the red oak seems to be the only exception, although it is probable that if it were not for the cutting of some large tulips in 1871 tulip would appear in sizes beyond those of the present table.

It has been possible to make counts of annual rings in a few cases of trees overturned in the area by a severe wind storm June 26, 1931. These records are shown in Table 9. In estimating the age of such a tree, a considerable period of time must be allowed for early stages of growth, as such trees growing from the forest floor, are greatly repressed during the early years.

Table 9. Counts of annual rings of trees overturned by storms.

Diameter at cut	Distance from cut to base of tree	Annual rings at cut	Estimated age of tree in years
Beech			
22 in. (55.8 cm.)	43 in. (1.09 m.)	229	250
20 in. (50.8 cm.)	25 ft. (7.62 m.)	190	220
14 in. (35.5 cm.)	10 ft. (2.54 m.)	105	125
13.5 in. (34.3 cm.)	10 ft. (2.54 m.)	126	150
Sugar Maple			
27 in. (68.6 cm.)	25 in. (76.2 cm.)	174	190
25 in. (63.5 cm.)	40 ft. (12.2 m.)	140	190
21 in. (53.3 cm.)	12 in. (30.5 cm.)	120	130
21 in. (53.3 cm.)	27 in. (68.6 cm.)	176	190
21 in. (53.3 cm.)	20 in. (50.8 cm.)	160	180
20.5 in. (52.1 cm.)	29 in. (73.7 cm.)	134	160
20 in. (30.8 cm.)	33 in. (83.8 cm.)	150	160
18 in. (44.7 cm.)	20 in. (50.8 cm.)	182	200
18 in. (44.7 cm.)	20 in. (50.8 cm.)	168	185
16 in. (40.6 cm.)	22 in. (55.8 cm.)	158	175
14 in. (35.5 cm.)	24 in. (61.0 cm.)	126	140
13 in. (33.1 cm.)	28 in. (71.1 cm.)	129	145
13 in. (33.1 cm.)	32 in. (81.3 cm.)	100	115
Hemlock			
22 in. (55.8 cm.)	20 in. (50.8 cm.)	164	175

A comparison of these tree sizes with the sizes of standing trees (Table 8) in the area shows that 39 per cent of the beeches and 13 per cent of the sugar maples making up this forest are as large, or larger, than the largest of which the annual rings were counted. This would indicate the age of the present forest to be well over 250 years.

The span of life of the sugar maple in this location seems to be determined by its size in relation to the soil. The humus is shallow, and the compact character of the subsoil seems to restrict the roots of this species to the soil above it—usually a matter of about 12 inches (30.5 cm.). Apparently few sugar maples above a certain size limit can long maintain them-

selves in this shallow soil against such severe wind storms as sometimes visit this forest. On the other hand, the life span of the beech seems to be determined by its susceptibility to fungus attack. There is probably no large beech tree in the area which is not hollow, at least at the base, the heartwood having been reduced to punk by the various species of fungi which seem to find an easy entrance to the tissues of this species. When finally the sapwood is affected, the tree will ultimately be twisted off its base by a wind storm, leaving the hollow stub standing. Apparently about 250 to 300 years is the limit of life for either the beech or the sugar maple in this location. There is need, therefore, for continual replacement of the dominants to make good the losses which more or less regularly occur.

The foregoing facts, taken together, clearly warrant the conclusion that in the area under study a gradual change in the status of the forest components has been in progress for some time, and the forces operating to bring about this change are operating at the present time. The conclusion that the hemlocks are being displaced by the beech and the sugar maple is inescapable. That the hemlocks formerly occupied much more territory than they now do is indicated by their remains in an area now completely occupied by the beech-maple association. In this movement the beech seems to play the leading part. Not only may beech hinder germination of hemlock by creating a humus unfavorable to the development of hemlock seedlings, but it may, by its dense shade, prevent the normal development of young hemlocks beneath its canopy, or by root competition in dry seasons reduce soil moisture available to neighboring hemlocks to the point where it ceases to be sufficient for hemlock requirements. The fact that beech roots more deeply than sugar maple in this environment may better fit it to play the part of entering wedge in displacing hemlock here. However, it may be expected that sugar maple will be more largely represented in this location in the future than it is now.

The need of plants for light is preëminent. Zon and Graves (1911) point out that early in life all plants are more or less tolerant of shade, but as they increase in size, their requirements for light become more and more definite, and that these requirements differ for different species. Burns (1923), studying the light requirements for 14 species of forest trees, found that each had a specific minimum requirement below which it could not live. The three trees with the lowest requirements he found to be, sugar maple lowest, beech next, and hemlock next. Daubenmire (1930), studying evaporation rate, light, soil acidity, and soil moisture under hemlock in Indiana, attempted to correlate the difference between hemlock and beech-maple. The results indicated an equal degree of mesophytism in the two associations. Studies of hemlock and its environment have been made by Moore, Richards, Gleason, and Stout (1924). While some slight differences were

found in the evaporation rate and in soil and air temperatures as compared with the hardwood forest, these do not seem significant enough to be recognized as controlling factors in the distribution of hemlock.

Apparently hemlock is not restricted in its location, as compared with the adjacent beech-maple association, by either temperature or moisture conditions, or by the chemical constitution of the soil; but rather, it is in process of elimination by competition within areas formerly occupied by it but now being gradually taken over by beech and sugar maple as dominants. The view that hemlock is thus being displaced is in accord with the opinion expressed by Weaver and Clements (1929) that the hemlocks of this region represent a remnant of the so-called "Lake Forest" to the north, returning with the retreat of the glacial ice, and now existing here only as small relict areas.

The fact that no chestnut saplings, and but very few smaller chestnut trees are to be found within the area, and that chestnut and hemlock were formerly very closely associated (Fig. 9) apparently on more or less even terms, leads the writer to the opinion that chestnut as well as hemlock would have fallen in competition with the beech-maple association, had not the "chestnut blight" wiped out the chestnuts before their time. For this reason chestnut may not be expected to "come back" in this environment naturally.

Undoubtedly the few oaks, hickories, sassafras, and other trees of subclimax types will gradually be eliminated through failure of reproduction, though sassafras has the great advantage of being able to reproduce by suckers from the roots. The presence of these trees, normally associated with the oak-chestnut forest, suggests an inter-relation of hemlock with oak-chestnut on the one hand, and beech-maple on the other, such as might have produced at one time an oak-chestnut-hemlock mictium which has now gone over to beech-hemlock.

That cucumber, and probably tupelo, have suffered displacement from the interior forest is clear, yet because of the steady though small reproduction rate of both species, and their commanding size when fully grown, they will probably continue for a long time as associates with the climax.

Secondary Succession

Under present conditions, the causes of secondary succession within the area are limited to denudations occurring by reason of the washing away of humus and top-soil at times of heavy rains, the slipping of earth and shale on the sides of the ravines due to erosion, and to the letting in of sunlight where breaks in the forest canopy occur because of the death of large trees which may either fall or remain standing, or whose tops or large branches may be broken off.

It is the uprooting of the large trees, exposing a more or less circular area of hard yellow clay, that causes most if not all of the secondary succession noted in the area by the writer. Such a depression may hold water for a large part of the year, and for this reason many seeds will not germinate upon it. From the edges of the torn mat of humus pokeweed is usually the first plant to appear. Commonly red-berried elder and high-bush blackberry are found along with the pokeweed. On the bare wet clay the spores of ferns, and the seeds of violets, wood sorrel, and great lobelia will germinate. Tulip and white ash frequently appear, but neither beech nor sugar maple will start on this surface.

From studies which have been started within the area in several localities where secondary succession is in process, but which cannot be reported on in detail here, it appears that tulip and white ash are the species that thrive, when the opportunty offers for rapid development in unoccupied territory. This accounts for the rather general distribution of these two species throughout the climax, both at the present time, and in the case of the tulip, formerly.

Ecological Classification of Plants

The dominant plants in any biotic community are considered to be those which, by reason of their size, abundance, and distribution, largely determine the conditions under which other organisms shall live in association with them. In the forest the dominants are usually trees. They are exposed directly to the sun, rain, snow, and wind; and other organisms mostly live underneath them. Beneath the trees temperature, light, evaporation rate, humidity, precipitation, wind, and other factors in the environment may be greatly modified. Only such plants and animals as are adapted to life under these conditions can exist here. The dominants therefore not only raise barriers against certain forms of plant and animal life—they invite others.

Primary dominants are those which, by reason of their wide and more or less even distribution and abundance, exercise their influence over the greater part of the community. Secondary dominants are those dominants which, by reason of their less frequent occurrence, do not exercise as great influence over the community as such. Their occurrence in the community, however, is rather regular. Incidental dominants, in this paper, are such trees as attain large size, and so exert an influence over a limited area, but which do not occur in numbers, or with any degree of regularity in the community. Subdominants are all other plants. They do not attain great size, but have adapted themselves to conditions of existence below the dominants. On this basis the plants of the area may be classified as in Table 10.

Table 10. Ecological classification of plants.

In beech-maple association	In beech-hemlock-oak-(chestnut) mictium	In ravines (flood-plain extensions)
	1. *Primary dominants*	
Beech Sugar Maple	Beech Hemlock (Chestnut)	Hemlock
	2. *Secondary dominants*	
Red Maple Tulip White Ash Northern Fox Grape	Red Maple Red Oak	
	3. *Incidental dominants*	
Shagbark Hickory Cucumber Red Oak White Oak	Shagbark Hickory Cucumber Tupelo Sassafras White Oak Wild Black Cherry Pignut Black Birch Scarlet Oak	American Elm Basswood Slippery Elm Butternut Black Walnut Bitternut
	4. *Sub- dominants*	
Hop Hornbeam American Hornbeam Shrubs, vines, herbs, ferns, and other plants, as listed in tables 6 and 7.	Hop Hornbeam American Hornbeam Flowering Dogwood Shadbush Shrubs, vines, herbs, ferns, and other plants as listed in tables 6 and 7.	Shrubs, vines, herbs, ferns, and other plants.

CHARACTER OF ANIMAL POPULATION

Methods of Study

Contrasted with the study of the plants of any area the study of its animal population presents an entirely different and much more difficult problem. Animals do not "stay put" as do plants. If the ecologist would really learn to know the animal content of an area, he must become so familiar with it that he feels thoroughly "at home" in it, and should achieve, in some degree at least, such a sympathetic attunement to the ebb and flow of its life activities that he becomes conscious of changes while they are in progress, and senses the significance of small matters as they arise. He must acquire the ability to move quietly and easily about, making a minimum of disturbance, while the senses of sight, hearing, and smell bring him information for his record.

While the methods of study of animals in their natural habitats must vary in accordance with the season, and often with the species studied, there are some general methods which, if carefully followed, should always offer a fair chance of definite returns. Such general methods as were used by the writer in this study were:

1. Regular and frequent visitation of the area. The writer was fortunately so situated that he could and did devote the Mondays of each week throughout the entire four years of this study to such visitation, with the exception of six scattered weeks, when observations were made by others under his direction. Familiarity with the area and its inhabitants was thus built up, and a picture of consecutive changes as they occurred secured, which probably could have been realized accurately in no other way. In addition to these extended weekly observations it was often possible to augment the record by more limited occasional visits in connection with other matters.

2. An increasing keenness of observation and interpretation of things seen and heard was deliberately sought after. A bird's feather on the ground, the scattered remnants of a meal, a dead shrew on a log, the droppings of animals, the barred owl's cast pellets, the character of woodpecker "workings," and many sounds and smells, all raised questions for which the correct answers were sought, even though considerable time might elapse between question and answer, and sometimes experiment was necessary for the solution of the problem.

Thus the presence of a heretofore unsuspected mammal (later confirmed by securing two specimens in the flesh) was determined through the discovery of the tiny jaw bone of the smoky shrew; and a method of ascertaining the presence of the seldom-seen flying squirrel was worked out by feeding hickory nuts to several species of captive squirrels, and noting that the flying squirrel, (and in fact the other species also) left a characteristic "signature" upon the nut shell.

3. Orderly routine in observation and recording on the spot. On each weekly visit the same course was followed, covering the entire area. Frequently the direction of travel was reversed, so that the same part of the area might be visited at different times. During this weekly survey an effort was made to identify accurately each species seen or heard; to make as complete a count of individuals as possible, or in the case of large numbers, to make a close estimate of numbers based on unit counts; to locate the occurrence of each individual on a small map carried for the purpose each week; to make notes of conditions of weather, changes in the plant or animal life observed, activities, relationships, or other facts considered significant. As this work was, with the few exceptions noted, always performed by the same person, usually alone, differences which might be due

to individual variances were eliminated, and the resultant data should be fairly comparable from one period to another. In estimating populations which are not restricted either to beech-hemlock or beech-maple environment, account does not have to be taken for what Leopold (1933) calls "blanks," as the entire area is essentially "forest" throughout. Even the area of the trails does not have to be figured out, as these are a very much used part of the habitat. All observations were recorded under appropriate headings on a temporary record carried for the purpose, and later transcribed to a permanent record, usually on the evening of the same day.

4. Concentration, at times, on special phases of animal behavior. Such were the studies of animal tracks in the snow, the location of the nesting territories of birds, and the home ranges of mammals, the study of food habits as special opportunities presented themselves, and the special study of the abundance and distribution of mice and shrews.

5. Visitation of the area at night. As the activities of some animals are carried on mainly after dark, it was considered of importance to visit the area a number of times, for varying periods, during the hours of darkness.

6. Observation of captive animals. While it is recognized that animals in captivity undoubtedly behave differently than in a state of natural freedom, it is also evident that much may be learned as to the character of the animal, and some understanding gained as to its equipment to meet competition in its natural environment, from a study of it at close quarters, even though under restraint. Opportunities were at hand during the summers to thus become acquainted with the New York weasel, raccoon, opossum, skunk, woodchuck, cottontail rabbit, red squirrel, chipmunk, flying squirrel, white footed mouse, pine mouse, barred owl, Cooper's hawk, red-tailed hawk, red-shouldered hawk, crow, and pilot blacksnake.

The Mammals of the Area

Table 11 gives the list of mammals whose presence in the area is known from direct observation. Representatives of all of these except the Virginia deer and the fox squirrel have been in the hands of the writer at various times, and skins of all of the species of mice, shrews, moles, bats, and chipmunk are deposited with the Cleveland Museum of Natural History. Scientific names are as given in the List of North American Recent Mammals, Bulletin 128 of the United States National Museum, with the exception of the eastern chipmunk, which is described by Howell (1929).

While the numbers and relative abundance of mammals in the area will always be subject to considerable fluctuation, the common species listed in Table 11 will usually be found in the order given; the most abundant being placed first. For the less common species enough information is not yet at hand to warrant an attempt to estimate abundance.

TABLE 11. The mammals of the area.

Common species	
Short-tailed Shrew	*Blarina brevicauda talpoides* (Gapper).
Northern White-footed Mouse	*Peromyscus leucopus noveboracensis* (Fischer).
Eastern Chipmunk	*Tamias striatus fisheri* Howell.
Northern Gray Squirrel	*Sciurus carolinensis leucotis* (Gapper).
Southern Red Squirrel	*Sciurus hudsonicus loquax* Bangs.
Small Eastern Flying Squirrel	*Glaucomys volans volans* (Linnaeus).
Cottontail Rabbit	*Sylvilagus floridanus mearnsi* (Allen).
Southern Woodchuck	*Marmota monax monax* (Linnaeus).
Eastern Raccoon	*Procyon lotor lotor* (Linnaeus).
Eastern Skunk	*Mephitis nigra* (Peale and Beauvois).
Virginia Opossum	*Didelphis virginiana virginiana* Kerr.
Eastern Red Fox	*Vulpes fulva* (Demarest).
Domestic Dog	
Domestic Cat	
Less common species	
Smoky Shrew	*Sorex fumeus fumeus* (Miller).
Hairy-tailed Mole	*Parascalops breweri* (Bachman).
Star-nosed Mole	*Condylura cristata* (Linnaeus).
Silver-haired Bat	*Lasionycteris noctivagans* (Le Conte).
Big Brown Bat	*Eptesicus fuscus fuscus* (Beauvois).
Red Bat	*Nycteris borealis borealis* (Müller).
New York Weasel	*Mustela noveboracensis noveboracensis* (Emmons).
Fox Squirrel	*Sciurus niger rufiventer* (Geoff.).
Pine Mouse	*Pitymys pinetorum scalopsoides* (Audubon and Bachman).
Meadow Mouse	*Microtus pennsylvanicus pennsylvanicus* (Ord).
Hudson Bay Jumping Mouse	*Zapus hudsonius hudsonius* (Zimmerman).
Woodland Jumping Mouse	*Napaeozapus insignis insignis* (Miller).
Virginia Deer	*Odocoileus virginianus virginianus* (Boddaert).

The above list of 25 mammals (omitting dog and cat) contains 49 per cent of the entire list of mammals (51) listed by the Ohio Department of Agriculture as now to be found in the State (Bull. 54, Bureau Scientific Research, 1931).

That the bison (*Bison bison* (Linnaeus)), American elk (*Cervus canadensis canadensis* (Erxleben)), Virginia deer (*Odocoileus virginianus virginianus* (Boddaert)), black bear (*Ursus americanus americanus* (Pallas)), and panther (*Felis cougar* Kerr) were once abundant in this region is attested by early writers. In view of the fact that all of these animals were completely exterminated from northern Ohio many years ago, it is interesting to find evidence of the return of one of them, the Virginia deer, to the locality. In view of the present overstocked condition of the deer ranges in western Pennsylvania (Clepper 1931) it would not be surprising to find deer wandering into northeastern Ohio from that direction.

DISTRIBUTION AND ABUNDANCE OF MAMMALS

In late July and early August 1932 some line trapping with spring mouse traps throughout the area demonstrated the very general distribution of short-tailed shrews and white-footed mice in all parts of the forest. It appeared that a catch could be made at every stump, or decaying log, or litter of sticks. Tunnels and runways were also found everywhere under the humus and

loose leaf-litter. Apparently the habitat was then occupied to the saturation point by mice and shrews. From a third to a half of the 98 animals trapped were either wholly or partially eaten, though the traps were inspected daily, and were usually under cover. This in itself indicated a large shrew population. The conditions of that autumn have not been duplicated since.

In late September and early October of the same year a more definite attempt was made to secure data that could be used as a basis for estimating the number of these two animals. Five quadrats were laid out in carefully selected territory, each 10 meters (32.75 feet) square. The location chosen for each was such as to make it typical of the whole area. Two were in beech-hemlock environment, and three were in beech-maple. One of the three in beech-maple environment had in it no stumps or logs or cover of any kind except the humus and leaf litter of the forest floor. The others included various types of shelter such as are commonly distributed over the area—tree roots, old logs, stumps and the like. Mouse traps of the usual spring-catch variety were used, baited with both oatmeal and raw beef, and usually set in groups of threes in runways that showed evidence of use, or in sheltered places. Trapping in each quadrat was continued until several days had passed without a catch. Usually this meant about two weeks of total time. It was then assumed that all of the mice and shrews using the quadrat as a hunting ground had been captured. Traps were inspected daily, often more frequently. Careful records were kept.

If the average catch of all five quadrats is taken as representing the population of an average 10 meter square for the whole area, then the population may be computed for any unit of the area. Later studies (unpublished) made by Mr. B. P. Bole, Jr., of the Cleveland Museum of Natural History, have demonstrated that the drift of small mammals from neighboring territory into the quadrat, especially at times when populations are high, is greater than was realized at the beginning of this study. It was originally felt that an offset existed in the loss of animals eaten and removed from the traps, large enough to counterbalance the entrance of others into the quadrat during trapping operations. The figures given in Table 13 for short-tailed shrews and white-footed mice are therefore undoubtedly too high, yet they are used in this paper as they establish a basis for comparisons with subsequent years during which the same trapping methods have been followed.

Accordingly, in September 1933 five quadrats of the same size as those used in 1932 were set up adjoining the quadrats of 1932, and trapped. The original five quadrats were again trapped in the autumn of 1934, and again in the autumn of 1935. Four consecutive groups of annual records were thus provided. In addition to indicating the distribution and abundance of short-tailed shrews and white-footed mice, these operations revealed the

presence of certain other species of small mammals—namely, Hudson Bay jumping mouse, woodland jumping mouse, pine mouse, meadow mouse, smoky shrew, and star-nosed mole. The results of the quadrat trapping are given in Table 12.

TABLE 12. Trapping records of mice and shrews.

Quadrats	A-beech-maple				B-beech-hemlock				C-beech-maple				D-beech-hemlock				E-beech-maple				Totals			
Years	'32	'33	'34	'35	'32	'33	'34	'35	'32	'33	'34	'35	'32	'33	'34	'35	'32	'33	'34	'35	'32	'33	'34	'35
Short-tailed shrew	10	4	2	8	12	0	0	2	5	3	1	4	6	2	1	5	4	3	2	4	37	12	6	23
White-footed mouse	8	1	0	3	3	0	0	5	6	0	0	4	5	3	1	7	6	1	3	8	28	5	4	27
Hudson Bay jumping mouse													1								1			
Woodland jumping mouse					1																1			
Pine mouse											2	5								2			2	7
Meadow mouse								1																1
Smoky shrew			1				1																2	
Totals	18	5	3	11	16	0	1	8	11	3	3	13	12	5	2	12	10	4	5	14	67	17	14	58

By reducing square meters to acres, and averaging the catch of all five quadrats annually for shrews and mice, an estimate of the numbers of these animals on an acreage basis may be secured. These figures are shown in Table 13. For convenience the estimated numbers of the other common mammals of the area are also shown in this table. These are based, not on trapping records, but on weekly counts of numbers, studies of tracks on the snow in winter, and other evidence. The fact that the two species of jumping mice do not appear from the trapping records to be of general distribution within the area, and the actual limits of their habitats being unknown at the present time, makes it impossible to include these species in the estimate. The occurrence of the meadow mouse in 1935 is considered not to represent a resident animal, but rather one migrating through the area. The four records of the occurrence of the smoky shrew (2 in traps, 1 jawbone found, remains of 1 in an insect trap) at widely separated points, two of which were in beech-hemlock, and two in beech-maple environment, suggest the general distribution of this animal throughout the area, and estimates of numbers are given. The case of the pine mouse presents an interesting situation. Previous to 1934 there was no evidence of the presence of this species in the area. The capture of 2 individuals (1 female, 1 immature male) in one quadrat well within the interior forest (beech-maple) in 1934 indicated small numbers and limited distribution. In 1935, although but 7 captures were recorded in the quadrats (Table 12), 12 others were caught in various ways (the writer caught one by hand) at such widely separated points within the area as to make it certain that the species was then well established in all parts of it.

TABLE 13. Common mammal population of the area—numbers of individuals.

Species	Autumn 1932			Autumn 1933			Autumn 1934			Autumn 1935		
	Per acre	*Per hectare	Total in area	Per acre	Per hectare	Total in area	Per acre	Per hectare	Total in area	Per acre	Per hectare	Total in area
Short-tailed shrew	299.45	739.6	19464.	97.12	239.8	6312.	48.56	119.9	3156.	187.	461.8	12165.
White-footed mouse	218.52	539.7	14203.	40.46	99.9	2629.	32.37	79.9	2104.	209.8	518.1	13635.
Pine mouse	.....	.....	.....	.....	.....	.....	8.1	19.8	525.	24.2	59.7	1575.
Chipmunk	10.0	24.7	650.	4.0	9.9	260.	10.0	24.7	650.	15.0	37.0	975.
Smoky shrew	.....	.....	.....	.....	.....	.....	8.1	19.8	525.	4.0	9.8	260.
Gray squirrel	0.03	0.07	2.	0.31	0.74	20.	0.9	2.2	60.	1.0	2.4	65.
Red squirrel	0.31	0.74	20.	0.23	0.57	15.	0.31	0.74	20.	0.5	1.2	30.
Cottontail rabbit	0.46	1.14	30.	0.61	1.48	40.	0.03	0.07	2.	0.06	0.15	4.
Flying squirrel	.....	.....	.....	.....	.....	.....	0.37	0.91	24.	0.37	0.91	24.
Woodchuck	0.15	0.37	10.	0.06	0.14	4.	0.09	0.22	6.	0.06	0.15	4.
Raccoon	0.18	0.45	12.	0.15	0.37	10.	0.18	0.45	12.	0.18	0.45	12.
Opossum	0.03	0.07	2.	0.06	0.14	4.	0.03	0.07	2.	0.03	0.07	2.
Skunk	0.09	0.22	6.	0.09	0.22	6.	0.00	0.00	0.	0.00	0.00	0.
Red fox	0.03	0.07	2.	0.06	0.14	4.	0.01	0.03	1.	0.03	0.07	2.
Totals per acre	529.25	.....	.....	143.15	.....	.....	109.05	.....	.....	442.23	.....	.....
Per hectare	.....	1307.13	.....	.....	353.40	.....	.....	268.79	.....	.....	1091.80	.....
Total in area	.....	.....	34401.	.....	.....	9304.	.....	.....	7087.	.....	.....	28753.

*1 hectare = 2.47 acres.

The status of the moles and the bats in the area is not clear. The subsoil is ill-suited to the work of moles because of its hardness, and though earthworms are noted in the humus and in the soft wood of decaying logs, the tunnels of moles are rarely evident. Perhaps the loose leaf-litter may effectually conceal them. On the other hand, when the humus was reduced to the semblance of tinder during the dry spring and summer of 1933 and mole tunnels were for the first time noted in the drying stream-beds, they were few in number. For the present the writer assumes that the numbers of moles of all species in the area are quite limited. But two specimens have been taken, representing two species.

The bats are as elusive as the moles. Bats have never been noted in numbers, and only on the wing. They give the impression of passing over or through the area rather than of hunting within or over it. They are usually seen flying high, though Mr. Earl Cady reports having seen two large bats (big brown bats?) at 12:30 A.M. September 7, 1933, apparently busily feeding in the moonlight over a large patch of jewel-weed in the woods. In the latter part of August 1933 an attempt was made to determine at least the species of bats flying in the forest. Mr. Arthur B. Fuller of the Cleveland Museum of Natural History, on three different nights, by wing-shooting over a grape tangle in the beech-maple association, collected a total of 5 bats, of which 3 were big brown bats. Apparently this species is the common bat of the area.

FOOD CHAINS AND ECOLOGICAL NICHES

In summing up the relative importance of the mammals of the area account must be taken not only of their numbers, but also of the duration of the periods of their activity, and of their food-habits. Those mammals classed as the less common species (Table 11) are clearly of much less importance ecologically than are the common ones. If they were entirely removed from the area the probability is that little if any change would be apparent. Attention may therefore be centred upon the common species. Table 14 classifies these on the basis of duration of activities.

TABLE 14. Common mammals classified according to duration of activities.

	Active throughout the year	Active by day	Active by night	Inactive during winter
Short-tailed shrew	*	*	*	.....
White-footed mouse	*	.....	*	.....
Chipmunk	.....	*	.....	*
Gray squirrel	*	*	.....	.....
Red squirrel	*	*	.....	.....
Flying squirrel	*	.....	*	.....
Cottontail rabbit	*	*	*	.....
Woodchuck	.....	*	.....	*
Raccoon	.....	.....	*	*
Skunk	.....	.....	*	*
Opossum	.....	.....	*	*
Fox	*	*	*	.....

Probably the most ceaselessly active of these animals is the short-tailed shrew, though Shull (1907), who studied the habits of this mammal, expresses the opinion that "times of daylight are not selected by the shrew for its greatest activity." Yet the writer's observations do indicate considerable daylight activity for this little mammal. In the area under study the barred owl is a consistent hunter of the shrew by daylight. One can often locate shrews at work by the rustling movement of dry leaves on the forest floor by day as well as by night. Not infrequently one gets a glimpse of a shrew by day as he flashes from one opening of his tunnel to another, or he may sometimes be surprised at work by quickly removing or turning over the decayed log or piece of bark that serves as a roof for his runway. Traps set in the morning and inspected before dark frequently contain shrews. Sometimes the bait will be so quickly taken by shrews, after setting the trap in daylight, that the operator hears the snap as he turns away. That shrews are active at all seasons of the year is indicated by their tunnels under the snow, and their trails on its surface in winter.

Although the shrew is usually referred to as an insectivore, ecologically he might just as well be classed as a carnivore, for he is a hunter after fresh meat in any form, and in proportion to his size he needs a great deal of it. Shull (1907), studying the short-tailed shrew in a swampy habitat near

Ann Arbor, Michigan, found that in winter snails formed a part of the food supply. Meadow voles *(Microtus)* were also an observed part of the diet. It was found that vegetable foods offered to captive shrews were invariably rejected.

On the basis of experiments with captive shrews, Shull estimated that one short-tailed shrew, in one month, will eat:

	Number	*Per cent of total*
Meadow mice or equivalent in mice	8	40
Adult insects (size of May beetles — Lachnosterna)	90	20
Insect larvae (size of May beetles — Lachnosterna)	78	20
Earthworms 4 cm. long, contracted	53	5
Snails	18	15

In a different habitat the relative availability of the different items in the diet would certainly influence the proportions consumed. At North Chagrin undoubtedly the proportion of mice eaten would run higher both in number and per cent of total, as *Peromyscus* is smaller than *Microtus,* and the supply of snails would be considerably less. It is also probable that the proportion of insects, millipeds, and the like would run higher. Smaller shrews, like *Sorex,* would also be preyed upon. It is important to recognize the short-tailed shrew as more than an eater of insects.

Occupying the position of the most abundant mammal in the area, being the only one that approaches constant activity by day and by night, and at all seasons of the year, requiring an enormous amount of animal food at all times, and having no real check upon numbers except the barred owl, the short-tailed shrew appears as probably the most influential mammal in the area. He acts as an efficient check upon the numbers of mice and other species of shrew, and takes out of the humus and decaying logs and stumps an immense number of insects and their larvae and of other forms like millipeds, centipedes, sowbugs, and worms. It is not entirely fanciful to liken his network of under-cover tunnels and runways to a vast system of spider-webs, laid down for the same purpose as the spider's web—the ensnaring of his prey.

From the standpoint of numbers and all-year-round activity the white-footed mouse probably ranks second in importance in the area. Compared with the shrew, the white-footed mouse does not exhibit the same kind of high-tension activity. Johnson (1926) found experimentally that forest deer mice *(Peromyscus)* were nocturnal, with a well marked rhythm of activity, sinking to a minimum during daylight hours and reaching a high degree normally during the hours of darkness. Unlike the shrew, the mouse is directly dependent upon plant products for his main support. Although a rodent, he is not a strict vegetarian, however, but consumes considerable animal material. All of the captive white-footed mice observed by the

writer have always eagerly accepted insect food. Snails also are probably eaten (Cahn and Kemp, 1929).

Checks upon undue increase in numbers of mice exist in the short-tailed shrew, as noted above; the barred owl, whose cast pellets found in the area frequently contain remains of *Peromyscus;* and in the larger mammals of the flesh-eating group—skunk, raccoon, opossum, weasel, and fox.

The chipmunk should undoubtedly be placed third in importance among the mammals of the area on the basis of number and general distribution, even though he withdraws from above-ground activities at certain seasons of the year. While popularly credited with being a complete hibernator (Anthony, 1928, p. 243), this is certainly not the case with the chipmunks in the area under study. Except for the winter 1932-33, when the chipmunk population at North Chagrin was reduced to a very low ebb, the writer has observed chipmunks abroad throughout the winter months, sometimes with the temperature as low as 10° F. (-12.2° C.), and has noted their tracks in the snow indicating great activity at certain times in winter. Counts of as many as 58 in one morning, and 63 in another, both in February, suggest anything but complete hibernation at that time. In fact the writer is of the opinion that the entire chipmunk population was aroused to a high pitch of excitement by mating activities at that particular time.

The periods of the chipmunk's greatest activity at North Chagrin are from the first week in May to the middle of July, and from the middle of September to late November if the weather is good. There is a period of retirement underground from mid-July through August which is probably correlated with the physiological condition of moulting and renewing of the pelage. Howell (1929) mentions the fact that out of 1,349 specimens of *Tamias* examined by him, very few moulting specimens have been found. This is no doubt due to the animal's disappearance during the period of moult, so that relatively few moulting specimens would be encountered by collectors. Schooley (1934) thinks this disappearance, reported by others but not observed by him, is due to the summer breeding season.

The chipmunk, like the mouse, is dependent mainly on vegetable matter for his food supplies but also takes animal matter (Howell 1929, Cahn and Kemp 1929, Seton 1909). Captive chipmunks observed by the writer ate with great avidity all insects offered, and shells of snails are commonly found among the refuse on their feeding tables. In May and June the chipmunks at North Chagrin do a great deal of "rooting" in the humus after such food as the tubers of spring beauty, dwarf ginseng, Indian cucumber, and squirrel corn, or the root-stocks of trillium. In the fall, beech nuts, sugar maple seeds, and other nuts and seeds are gathered and stored underground.

Checks on the numbers of chipmunks in the form of larger predators

are not very apparent. It is possible that the fox and the weasel may exercise some influence, but direct evidence is lacking. Chipmunk remains have not been found in the casts of the barred owl in the area, nor has the owl been observed to hunt chipmunks. Cats have been definitely observed stalking chipmunks. Possibly the pilot blacksnake may be a definite consumer of chipmunks in summer. Under favorable conditions of food supply there seems to be no reason why the chipmunk population should not occupy all available habitats in the area—and this indeed seems frequently to be realized. Competition would then act to prevent overpopulation.

The other squirrels—red squirrel, gray squirrel, and flying squirrel—are all consumers of nuts, seeds, and fruits, as well as of some animal matter. Captive flying squirrels and captive red squirrels, under the observation of the writer greedily ate all insects offered them. As a group the arboreal squirrels are important members of the community by reason of their almost continuous activity throughout the year and their steady consumption of basic forest food supplies. Their function as destroyers of large numbers of insects must not be overlooked. Competition between species and individuals apparently acts as an efficient check upon numbers.

The rabbit and the woodchuck are normally rather unimportant elements in the biota of the area because of their small numbers. If either should increase greatly in abundance, and maintain their increased numbers for any considerable period of time, they might have a significant relation to the vegetation of the area by reason of their food requirements. The rabbit especially, under such conditions, might affect greatly the character of forest seedling trees and saplings. Such a condition has apparently never occurred, however. The very apparent check upon both of these animals is the red fox, about whose dens the remains of woodchucks and rabbits are very commonly found. Hamilton (1935) mentions rabbits as constituting 22.1 per cent by bulk, of the food of 206 foxes in fall and winter in New York and New England, and woodchuck remains stand highest in the list for 31 fox dens examined by him in July and August.

With the exception of the short-tailed shrew, the carnivores of the area have a larger sphere of activity than the 65 acres under study. Yet their regular visitation of it, and their resident character to some extent in the case of certain individuals, means a very considerable influence in its biotic relationships. The raccoon, the skunk, and the opossum may be regarded as somewhat in the nature of additional checks upon the undue increase of the smaller mammals. They undoubtedly limit to some extent the numbers of birds nesting on or near the ground. They must also be recognized as large consumers of insects, and of the so-called "cold-blooded" animals—crayfish, frogs, salamanders, and snakes. Their periods of greatest activity

correspond with those of the "cold-blooded" animals, and raccoons are especially diligent hunters of this sort of fare.

The weasel and the fox provide still further checks upon the smaller mammal population, and the fox especially seems important in limiting the number of rabbits.

Taken as a group, the mammals of the area illustrate well the adaptations of animals to a forest environment. Omitting the dog and the cat, which are associated with the presence of man in the near vicinity, and the deer, which is an occasional visitor only, and the meadow mouse, which we may consider a transient visitor, it appears that the 23 species remaining consist of 5 squirrels, 4 mice, 1 rabbit, 1 woodchuck (all chiefly herbivores); 2 shrews, 2 moles, 3 bats (all chiefly insectivores); and the raccoon, opossum, skunk, weasel, and fox (all chiefly carnivores). The composition of the whole group then, may be roughly indicated as:

Herbivores, 48 per cent.

Insectivores, 30 per cent.

Carnivores, 22 per cent.

This arrangement, however, is only a species grouping and does not indicate food relationships with any degree of exactness. Probably the weasel is the most nearly strictly carnivorous animal on the list, and the rabbit and the woodchuck the most nearly strictly herbivorous ones. Undoubtedly the squirrels and the mice consume great quantities of insects along with their mainly herbivorous diet, and this is true also of most of the carnivores. Even the red fox is accredited as an insect eater (Dearborn, 1932, and Hamilton, 1935). The bats, no doubt, are strictly insectivorous, but the moles and shrews are carnivorous as well as insectivorous. Most of those classed as carnivores might also be classed as omnivores. But the gist of the matter is that plant products, insects, and other invertebrates, are the mainstay of the mammal population of the area, while to a more limited extent the smaller mammals themselves serve to support the larger ones.

In their occupation of the territory it is interesting to see how these mammals have occupied fully all available habitats. The moles occupy the deeper parts of the substratum, so far as it is available to them; the shrews have appropriated the loose humus and leaf litter of the forest floor, using the runways of mice and moles as well; the chipmunks are animals of the floor itself and the débris that lies upon it in the shape of old logs, stumps, and litter, though making their homes and storehouses in tunnels that reach into the subsoil itself; the mice are inhabitants of logs and stumps and hollow trees and other forest litter, and the white-footed mouse is a climber of trees as well; the red squirrel, with his headquarters usually under some stump or bunch of roots, also ascends the trees, and frequently builds a nest in a grapevine suspended aloft; the gray squirrel is the true arboreal animal

of the area, spending much time aloft, using aerial runways by preference, and having his winter quarters usually high above the ground in some hollow tree top; the flying squirrel is also an arboreal animal, extending his aerial highways beyond the limits of those of the gray squirrel by reason of his abilities as an aerial glider; and the bats complete the occupation of all available habitats by hunting through the air itself.

The larger mammals of the list are mainly hunters upon the surface of the ground, though the raccoon and the opossum are climbers, and the raccoon's winter quarters are usually high above ground.

This division of territory and diversity of diet makes possible the support of a large population of mammals adapted to the limitations of the habitat, provided basic food supplies are present in normal quantities. In this particular forest this means beech nuts, sugar maple seeds, herbaceous vegetation, insects and other invertebrates.

Such was the condition in the autumn of 1931. At that time apparently every available habitat within the area was occupied to its upper limit of capacity by the shrews, mice, chipmunks, and gray squirrels. There had been very large yields of beech nuts and sugar maple seeds the previous autumn, as well as this autmun. Food supplies were more than adequate for even the large population then occupying the territory.

Fluctuations in Numbers of Mammals

As Elton (1927) has pointed out, the chief cause of fluctuation in animal numbers is the unstability of the environment. This is well illustrated in the case of the area under study by what happened in the autumn of 1932. This was the time of almost complete failure of the beeches and sugar maples to produce seed. Whether the resting rhythm of these two trees normally coincides, or whether it does so only occasionally because of a difference in length of rhythm, remains for further studies to determine. At any rate, basic food supplies practically disappeared just before the winter of 1932-33.

There was little storage of food by chipmunks that autumn, and they went underground almost a month earlier than the previous year when storage activities ran well into the last of November. Although there was no observation of the activities of the white-footed mice, the absence of their accustomed food supplies would have produced more or less of the same condition with them, so far as storage of winter food was concerned. The red squirrels, as appeared later, gathered and stored large quantities of tulip seed cones, and some of them subsisted upon scarcely anything else during the entire winter, as indicated by the refuse about their middens as the winter progressed. Hemlock seeds were also used by the red squirrels, but there was a deficiency in yield of these seeds also. Mushrooms were

much used. Seeds of cucumber trees, usually shunned as articles of diet, were freely gathered, stored and eaten by red squirrels that winter. These animals are probably naturally resourceful in the discovery and use of foods outside the usual list, as the droppings of horses were twice noted in red squirrel middens. These must have been discovered and brought in from near-by bridle paths. The fact that the red squirrels did not occupy the territory as fully as did the other rodents was also in their favor, for it is a recognized fact that competition within the ranks of a species is always keener than between different species, as the needs of the individuals are then identical. But the red squirrels were able to and did expand their individual territories, spreading into parts of the area not previously occupied by them.

The gray squirrels left the area early. About 50 of these animals occupied the area the previous winter, producing enough young in spring to keep their numbers fairly constant. But in September they moved out, leaving one lone squirrel to face the famine alone. This individual was frequently noted during the winter following. He seemed to be subsisting on a few hickory nuts, red oak acorns, tulip seeds, and mushrooms. The writer even saw him sampling the hard woody bracket of *Polyporus applanatus,* and later noted that the marks of squirrels' teeth on these unpalatable fungi were not at all uncommon that winter.

An interesting fact in connection with this winter was the increase in numbers of cottontail rabbits within the area. Previously they had been noted about the edges of the forest. Now they extended their feeding grounds into all parts of the area. Numbers were probably doubled, increasing from 20 to 40, and there was much evidence of their activities in the "barking" of young trees, and nipping off of the terminal buds and twigs of thousands of small trees of beech, sugar maple, and red maple. This meant the destruction of many seedlings, but of course in most cases they would necessarily have been eliminated by competition later. The rabbits naturally were not affected by the failure of beech nuts and sugar maple seeds, as their food consists of bark, buds, twigs, and the green leaves of the ferns, *Carex,* and other woodland plants such as *Hepatica* and *Dentaria diphylla* whose leaves remain green all winter.

During this winter not a single chipmunk was seen above ground, where counts of as high as 58 in a morning had been made the previous winter and have been made since. The following spring it was apparent that very few chipmunks had survived the winter, as only a few individuals were noted where usually the woods should have been "alive" with them.

The situation with regard to mice and shrews was not fully realized until the following autumn (1933) when the second attempt to estimate numbers by trapping was made. Then it appeared that the mice had suffered

a decrease of over 80 per cent, and the shrews a decrease of over 65 per cent (Table 15). The reduction in numbers of mice must have reacted directly upon the numbers of shrews, as mice enter so largely into shrew diet.

The summer of 1933 proved to be an especially dry one. The months of June, July, and August were devoid of any effective rainfall (Fig. 5). Such precipitation as did occur came in the shape of more or less violent rainstorms, with rapid run-off of water, and quick drying out of the surface leaves on the forest floor, which afforded no relief to the very dry condition of the humus. The Amphibia, Mollusca, and soft-bodied insects and larvae either perished or went into aestivation. This again meant a shortening of food supplies for the shrews. The mice apparently suffered more than the shrews as indicated by the shift in relative numbers of the two species (Table 15). Not only was their accustomed winter food supply lacking, but the shrews, on shortened rations, due to the disappearance of the insects and other invertebrateas, must have turned to the mice as acceptable food with more persistence than usual.

Table 15. Decrease in numbers of mice and shrews.

	1932	1933	1934	1935
Total numbers (5 quadrats):				
Short-tailed shrew	37	12	6	23
White-footed mouse	28	5	4	27
Relative proportions (percentage of shrews to mice):				
Short-tailed shrew	58	70.6	60	46
White-footed mouse	42	29.4	40	54
Per cent of decrease as compared with 1932:				
Short-tailed shrew	....	67.6	83.8	37.5
White-footed mouse	....	81.4	85.2	4.0

With the short-tailed shrew present in the numbers indicated in the autumn of 1932 (Table 13), one has only to attempt to visualize the enormous amount of animal food necessary for its support to sense the shrew population collapsing under its own weight. This explains the avidity with which baits were taken that autumn; the speedy devouring of so many of the animals trapped; the extension of runways into almost every square foot of ground; the absence in the traps of any other species of shrew. So far as the writer's observation goes, the only real check upon the numbers of shrews in the area was one pair of barred owls and their two young. All barred owl pellets thus far found in the area have, without exception, contained skulls or jaws of *Blarina brevicauda* as well as other material.

If, under optimum conditions, such as apparently existed in 1932, the shrew population got "out of bounds," so to speak, in the absence of sufficiently strong checks, then competition within the species itself would auto-

matically operate to reduce numbers. But as has been indicated, other and even more potent forces were already at work.

Coincident with the increase in the number of rabbits in 1932, there was an increase in the number of foxes hunting in the area, as shown by tracks in the snow in the winter of 1932-33. The number of rabbits was estimated at 40 in January, 1933. On January 15, 1934, with a fine tracking snow on the ground for several days, it was apparent that only 2 rabbits were then inhabiting the area. On the other hand the snow showed the presence of at least 4 hunting foxes—two more than the previous winter. Perhaps the decimation of the numbers of mice and squirrels which may be looked upon as "buffer food," had compelled closer attention to rabbit hunting on the part of the fox population. It is a recognized fact that there always seems to be a perceptible lag in the abundance of the carnivore as related to abundance of food supply (Elton 1927). The record of the snow the following winter (1934-35) showed one fox and no rabbits in the area.

The total disappearance of the skunk following the great reductions in numbers of mice, and the drying out of the humus insects in the summer of 1933 is another significant correlation. So also is the reduction in numbers of the pilot blacksnake.

The yield of beech nuts was again ample in the autumn of 1933 and of 1934, but the sugar maple did not come into bearing again until 1934. The first mammal to show recovery in numbers from the disturbed conditions of 1932 was the chipmunk. There was apparently a small spring brood, and also a summer brood, in 1933; the usual winter activity and a large emerging chipmunk population in the spring of 1934. Apparently numbers were completely recuperated during 1934, and the area seemed to have about all the chipmunks it would normally support. But 1935 proved this assumption wrong, for numbers were again increased. Incidentally this was true not only of the area under study, but chipmunks reached abnormally large numbers throughout the Chagrin valley and elsewhere in the vicinity of Cleveland. The speedy return of the species to normal numbers in the area under study is a notable demonstration of rapid response to favorable conditions in the environment. These must have been close to optimum to have produced such a result.

On the other hand the numbers of shrews and mice continued to drop, so that in the autumn of 1934 trapping records showed a decrease of over 16 per cent for the shrews and almost 4 per cent for the mice as compared with 1933. The shrews were now apparently suffering more than the mice, which would be expected because of the complete restoration of food supplies for the mice but not for the shrews.

The appearance of the pine mouse and the smoky shrew in the traps for the first time (1934), when the numbers of their arch competitor and prob-

able deadly enemy the short-tailed shrew was reduced to a comparatively low figure, seems to indicate that these animals may prosper only when the numbers of the short-tailed shrew are relatively small. Possibly their curve of abundance may fluctuate inversely with that of the short-tailed shrew.

The year 1935 proved to be a "mouse year" at North Chagrin. It witnessed the return of the white-footed mouse to numbers within 4 per cent of the high figures of 1932. The short-tailed shrew showed a substantial increase in numbers over 1934, but was still 37.5 per cent below 1932 numbers. This shift in relative proportions (Table 15) made the white-footed mouse, for the first time during the four years of this study, the most abundant mammal of the area. A new mammal, the pine mouse, appearing first in 1934, became common in the area. As evidence of the pressure of numbers of mice outside the area, the meadow mouse, not normally found in the forest, appears far within the forest boundaries.

Although the foregoing discussion of fluctuations in numbers of mammals is far from complete, yet enough evidence seems to have come to the surface to show how far-reaching a disturbance of the so-called "balance" of nature may be. In this case the disturbance is partly the normal rest in the bearing rhythm of the forest dominants, and partly the abnormal break in the climatic factor of precipitation of moisture. Only in the case of the skunk is there any direct evidence of disease having been a factor in the situation. Competition between individuals and between species seems to have been largely the keen-edged instrument whereby numbers were cut down after the failure of basic food supplies.

The Birds of the Area

As contrasted with the mammals, the birds of the area constitute at times a very rapidly shifting element in the community. From the standpoint of time spent within the area the birds may be divided into the following groups. Scientific names and the order of listing are as given in the American Ornithologists' Union Check List of North American Birds, Fourth Edition, 1931.

Table 16. Birds of the area by seasonal groups.

1. Permanent residents

(Species found in the area throughout the year)

Eastern Ruffed Grouse	*Bonasa umbellus umbellus* (Linnaeus).
Northern Barred Owl	*Strix varia varia* Barton.
Northern Pileated Woodpecker	*Ceophloeus pileatus abieticola* Bangs.
Red-bellied Woodpecker	*Centurus carolinus* (Linnaeus).
Eastern Hairy Woodpecker	*Dryobates villosus villosus* (Linnaeus).
Northern Downy Woodpecker	*Dryobates pubescens medianus* (Swainson).
Blacked-capped Chickadee	*Penthestes atricapillus atricapillus* (Linnaeus).
Tufted Titmouse	*Baeolophus bicolor* (Linnaeus).
White-breasted Nuthatch	*Sitta carolinensis carolinensis* Latham.
Eastern Cardinal	*Richmondena cardinalis cardinalis* (Linnaeus).
Red-eyed Towbee	*Pipilo erythrophthalamus erythrophthalamus* (Linnaeus).

2. Autumn and winter visitors

(Species found more or less continuously in the area only in the autumn and winter months)

Northern Blue Jay	*Cyanocitta cristata cristata* (Linnaeus).
Red-breasted Nuthatch	*Sitta canadensis* Linnaeus.
Brown Creeper	*Certhia familiaris americana* Bonaparte.
Winter Wren	*Nannus hiemalis hiemalis* (Vieillot).
Carolina Wren	*Thryothorus ludovicianus ludovicianus* (Latham).
Eastern Golden-crowned Kinglet	*Regulus satrapa satrapa* Lichtenstein.
Eastern Goldfinch	*Spinus tristis tristis* (Linnaeus).
Slate-colored Junco	*Junco hyemalis hyemalis* (Linnaeus).

3. Summer residents

(Species found continuously in the area only during spring and summer)

Northern Crested Flycatcher	*Myiarchus crinitus boreus* Bangs.
Eastern Phoebe	*Sayornis phoebe* (Latham).
Acadian Flycatcher	*Empidonax virescens* (Vieillot).
Eastern Wood Pewee	*Myiochanes virens* (Linnaeus).
Eastern Robin	*Turdus migratorius migratorius* Linnaeus.
Wood Thrush	*Hylocichla mustelina* (Gmelin).
Yellow-throated Vireo	*Vireo flavifrons* Vieillot.
Red-eyed Vireo	*Vireo olivacea* (Linnaeus).
Black-throated Green Warbler	*Dendroica virens* (Gmelin).
Cerulean Warbler	*Dendroica cerulea* (Wilson).
Oven-bird	*Seiurus aurocapillus* (Linnaeus).
Louisiana Water Thrush	*Seiurus motacilla* (Vieillot).
Hooded Warbler	*Wilsonia citrina* (Boddaert).
American Redstart	*Setophaga ruticilla* (Linnaeus).
Scarlet Tanager	*Piranga erythromelas* Vieillot.
Rose-breasted Grosbeak	*Hedymeles ludovicianus* (Linnaeus).

4. Transients

(Species found in the area only during their spring or autumn migration)

Yellow-bellied Sapsucker	*Saphyrapicus varius varius* (Linnaeus).
Yellow-bellied Flycatcher	*Empidonax flaviventris* (Baird and Baird).
Eastern Hermit Thrush	*Hylocichla guttata faxoni* Banga and Penard.
Olive-backed Thrush	*Hylocichla ustulata swainsoni* (Tschudi).
Gray-cheeked Thrush	*Hylocichla aliciae aliciae* (Baird).
Wilson's Thrush	*Hylocichla fuscescens fuscescens* (Stephens).
Eastern Ruby-crowned Kinglet	*Corythylio calendula calendula* Baird.
Blue-headed Vireo	*Vireo solitarius solitarius* (Wilson).
Black and White Warbler	*Mniotilta varia* (Linnaeus).
Blue-winged Warbler	*Vermivora pinus* (Linnaeus).
Nashville Warbler	*Vermivora ruficapilla ruficapilla* (Wilson).
Magnolia Warbler	*Dendroica magnolia* (Wilson).
Black-throated Blue Warbler	*Dendroica caerulescens caerulescens* (Gmelin).
Myrtle Warbler	*Dendroica coronata* (Linnaeus).
Blackburnian Warbler	*Dendroica fusca* (Müller).
Chestnut-sided Warbler	*Dendroica pennsylvanica* (Linnaeus).
Bay-breasted Warbler	*Dendroica castanea* (Wilson).
Blackpoll Warbler	*Dendroica striata* (Forster).
Connecticut Warbler	*Oporornis agilis* (Wilson).
Canada Warbler	*Wilsonia canadensis* (Linnaeus).
Eastern Purple Finch	*Carpodacus purpureus purpureus* (Gmelin).
White-throated Sparrow	*Zonotrichia albicollis* (Gmelin).
Eastern Fox Sparrow	*Passerella iliaca iliaca* (Merrem).

5. Occasional visitors

(Species noted only occasionally in the area)

Turkey Vulture	*Cathartes aura septentrionalis* Wied.
Sharp-shinned Hawk	*Accipiter velox velox* (Wilson).
Cooper's Hawk	*Accipiter cooperi* (Bonaparte).

Eastern Red-tailed Hawk	*Buteo borealis borealis* (Gmelin).
Broad-winged Hawk	*Buteo platypterus platypterus* (Vieillot).
Eastern Bob-white	*Colinus virginianus virginianus* (Linnaeus).
American Woodcock	*Philohela minor* (Gmelin).
Eastern Mourning Dove	*Zenaidura macroura carolinensis* (Linnaeus).
Yellow-billed Cuckoo	*Coccoyzus americanus americanus* (Linnaeus).
Great Horned Owl	*Bubo virginianus virginianus* (Gmelin).
Eastern Whip-poor-will	*Antrostomus vociferus vociferus* (Wilson).
Eastern Nighthawk	*Chordeiles minor minor* (Forster).
Chimney Swift	*Chaetura pelagica* (Linnaeus).
Ruby-throated Hummingbird	*Archilochus colubris* (Linnaeus).
Northern Flicker	*Colaptes auratus luteus* Bangs.
Purple Martin	*Progne subis subis* (Linnaeus).
Eastern Crow	*Corvus brachyrhynchos brachyrhynchos* Brehm.
Starling	*Sturnus vulgaris vulgaris* (Linnaeus).
Bronzed Grackle	*Quiscalus quiscala aeneus* Ridgway.
Eastern Cowbird	*Molothrus ater ater* (Boddaert).
Canadian Pine Grosbeak	*Pinicola enucleator leucura* (Müller).
Eastern Blue Grosbeak	*Guiraca caerulea caerulea* (Linnaeus).
Indigo Bunting	*Passerina cyanea* (Linnaeus).
Common Redpoll	*Acanthis linaria linaria* (Linnaeus).
Red Crossbill	*Loxia curvirostra pusilla* Gloger.

The fact that the blue jay and the Carolina wren are included in the above list as autumn and winter visitors, rather than as permanent residents, may seem strange to one familiar with the birds of the Cleveland region, yet from the standpoint of the forest areas under study this is their status. The record of the blue grosbeak is unusual— a single record of a pair observed by the writer under favorable conditions May 15, 1933, in one of the grape tangles of the area.

Distribution and Abundance of Birds

Those birds nesting in the beech-hemlock environment only were the black-throated green warbler and probably the ruffed grouse. Those nesting in both beech-maple and beech-hemlock were the wood pewee, wood thrush, and ovenbird. The other species on the lists of permanent and summer residents nested exclusively in the beech-maple association. Most of the transient species were observed in beech-maple environment, while the winter bird companies roamed about the whole area.

The transient species, with the exception of the robins, thrushes, and certain warblers, do not bulk large in numbers. Estimates of 500 robins, 200 thrushes, and 300 warblers have been made at certain times. Autumn and winter visitors are irregularly present except in the case of the slate-colored junco and red-breasted nuthatch. Flocks of from 50 to 60 juncos have been noted, and the red-breasted nuthatch, present in alternate years, sometimes totals 50 to 60 in number.

The permanent resident species became quite well known. The number of hairy and downy woodpeckers, chickadees, tufted titmice, and white-breasted nuthatches are augmented considerably at times during the winter. Whether or not the actual birds nesting in the area in summer are present also in winter is not definitely known. Butts (1930) determined by band-

ing methods that individual chickadees, banded in winter, nested in or quite near their winter feeding territory, and that individual white-breasted nuthatches nested within or very close to their winter feeding area.

The barred owl, the pileated woodpecker, the ruffed grouse, and the cardinal are not usually present in greater numbers in winter than in summer. The towhees congregate in the woods in winter, but in spring most of them leave the area. These probably constitute the towhees nesting just outside the forest, though usually a pair or so may be found nesting just inside the forest edge.

Careful records of the numbers of birds observed on the weekly surveys of the area have been kept over the entire period of this study. The observed occurrence of the bird has been located on a map of the area carried each week for the purpose. Thus the species-constitution, numbers, and territories of the winter bird companies have been determined, the distribution of species and individuals noted, and summer nesting territories charted. While these figures (on their face) reflect seasonal fluctuations, they need considerable interpretation when it comes to studying absolute abundance. Weather conditions influence the count greatly at times. High winds, and storms of snow or rain reduce the number of birds observed. The appearance of the foliage on the forest trees in May is comparable to the dropping of a heavy curtain so far as visibility is concerned. Then sight records are largely replaced by those of hearing. When the song period is over it is quite difficult at times to get evidence of the presence or absence of birds. Chickadees, titmice, nuthatches, and woodpeckers become furtive and inconspicuous at the approach of, and during the nesting season. Differences in weekly counts at times reflect changes in activities or behaviour rather than fluctuations in abundance.

Perhaps the most reliable index to abundance of birds is the record of nesting pairs. By the use of the weekly maps, described above, it is possible to build up a series of maps (one for each species) covering the nesting season, which will show concentrations of records about certain localities. The localities thus indicated may be considered as within the territories of breeding pairs, and it is thus possible to estimate the numbers of breeding pairs of birds throughout the entire area and the approximate extent of the territory occupied by each. Figure 14 is presented as an illustration of this method, the species chosen being the hooded warbler, one of the common nesting species of the area. As nests are actually found, even though it may be during the following winter, their location with reference to the recorded location of the individual birds on the map makes it appear that this method may be relied upon to reveal the presence of a nesting pair or lone male, and fix the approximate limits of the nesting territory.

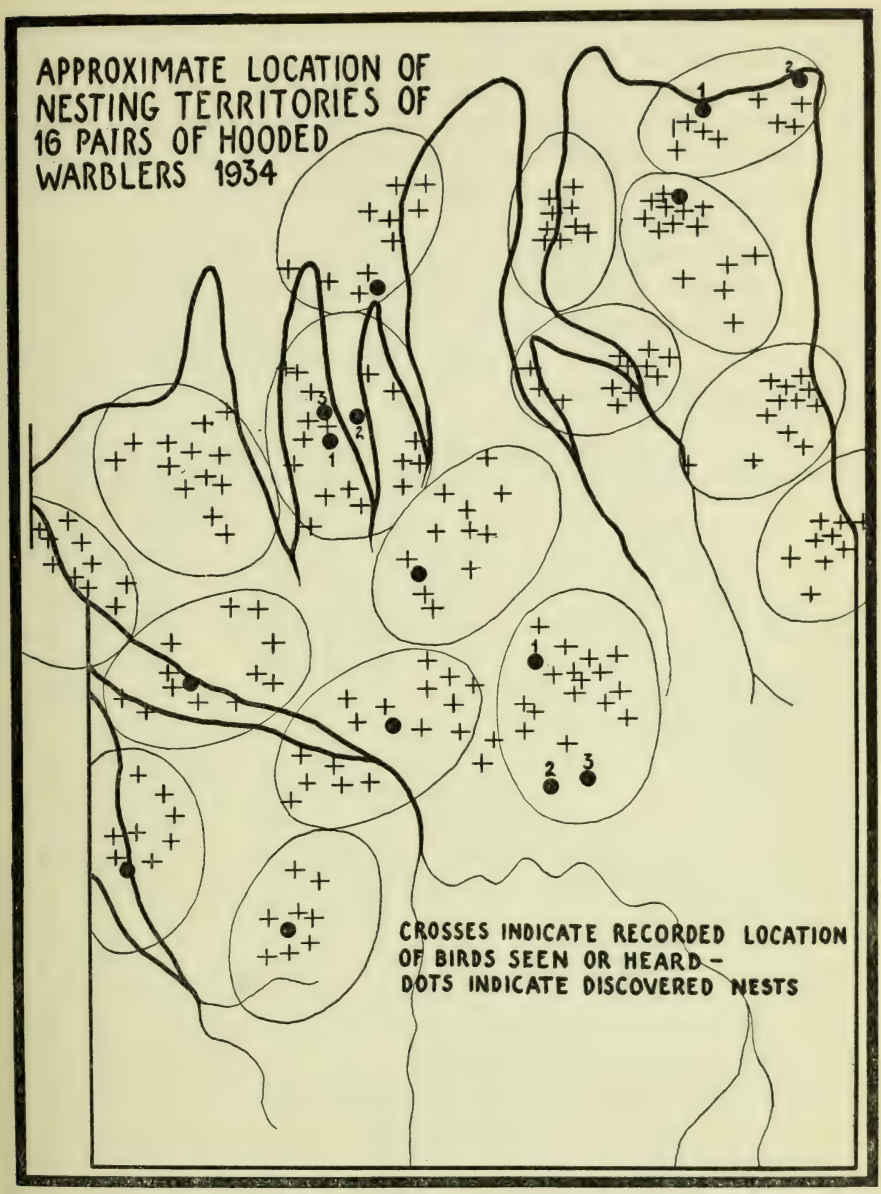
APPROXIMATE LOCATION OF NESTING TERRITORIES OF 16 PAIRS OF HOODED WARBLERS 1934
CROSSES INDICATE RECORDED LOCATION OF BIRDS SEEN OR HEARD—
DOTS INDICATE DISCOVERED NESTS

Fig. 14. Approximate nesting territories of hooded warblers in the area under study in 1934, on the basis of records made throughout the nesting season. First, second, and third nests of the same pair are numbered.

Schiermann (1930), studying the density of population of breeding birds in a forest in Brandenburg, Germany, adopted the method of laying out quadrats 250 meters (820.1 feet) square, and then searching systematically for every nest within the quadrat. From these sample quadrats the num-

ber of nesting pairs of birds in the whole area was then estimated. Schiermann found that his statistical results obtained from the quadrat agreed closely with figures arrived at from frequent visits to the area over a period of six years. He concludes, however, that his quadrats are of help only in conjunction with an intimate knowledge of the area obtained from long contact with it. With this conclusion the experience of the writer agrees.

The complete record of nesting birds in the area under study, as determined by the method of charting observed occurrences of the birds on a map, for the summers of 1932, 1933, 1934, and 1935 is shown in Table 17. Second and third attempts at nesting are not counted in this tabulation, but only the number of pairs of birds.

TABLE 17. Numbers of nesting pairs of birds.

Species	Numbers of Pairs			
	1932	1933	1934	1935
1. Red-eyed Vireo	25	36	35	30
2. Wood Thrush	17	25	22	14
3. Hooded Warbler	15	15	16	9
4. American Redstart	12	17	19	19
5. Oven-bird	11	18	16	8
6. Tufted Titmouse	7	8	6	7
7. Black-capped Chickadee	6	5	3	2
8. Eastern Wood Pewee	6	7	7	7
9. Scarlet Tanager	6	6	10	9
10. Eastern Cardinal	5	5	5	4
11. Yellow-throated Vireo	4	4	7	3
12. Acadian Flycatcher	3	3	6	2
13. White-breasted Nuthatch	3	3	4	4
14. Black-throated Green Warbler	3	3	5	3
15. Red-eyed Towhee	3	1	2	1
16. Cerulean Warbler	2	2	1	0
17. Northern Downy Woodpecker	1	4	5	2
18. Eastern Hairy Woodpecker	1	3	3	3
19. Northern Crested Flycatcher	1	2	1	2
20. Eastern Phoebe	1	2	0	1
21. Northern Barred Owl	1	1	1	1
22. Eastern Robin	1	1	1	1
23. Louisiana Water Thrush	1	1	0	1
24. Northern Pileated Woodpecker	1	0	0	0
25. Northern Flicker	0	1	0	0
26. Rose-breasted Grosbeak	0	1	0	1
27. Red-bellied Woodpecker	0	0	1	0
28. Eastern Ruffed Grouse	?	0	0	0
29. Eastern Cowbird	*present*	*present*	*present*	*present*
Total pairs	136	174	176	134
Total individuals	272	348	352	268
Pairs per acre	2.0	2.6	2.7	2.0
Pairs per hectare	4.9	6.4	6.7	4.9
Average number pairs per acre, 4 years				2.3
Average number pairs per hectare, 4 years				5.7

It will be noted that the summer of 1933 showed a slight increase in numbers of nesting pairs, as contrasted with the great decrease in the mammal population of this period. The birds were unaffected by the failure of beech and sugar maple seeds, as these are not "basic" foods for them, as they are in the case of most of the mammals. They were also not affected by the dry weather of the summer so far as nesting activities were concerned, as the drought was most severe during late June, July, and August, when nesting activities were about over. If the bird population was affected by reduced numbers of insects following the drought, or if reproduction was cut down during the breeding season one would expect it to be reflected in the numbers of breeding pairs in 1934.

Figure 15 shows the approximate locations of the nesting sites of the 176 pairs of birds listed in Table 17 as having been recorded in 1934. As this figure is studied it should be kept in mind that we have here not only a horizontal distribution of nesting sites, but a vertical one as well, ranging from the tops of large trees, as in the case of the cerulean warbler, down through the various levels of forest growth to the nesting site of the ovenbird beneath the leaf-litter on the floor of the forest. Nesting territories may be separated from each other by distance vertically as well as by distance horizontally. The writer recalls one nest of the red-eyed vireo approximately 70 feet (21.3 meters) up, in a large beech tree, and another nest of the same species almost directly below it in a beech sapling about 6 feet (1.8 meters) from the ground. One vireo pair had a tree-top territory, the other almost a ground-level territory.

Using the breeding record as a basis for estimating the summer breeding population of birds, and the weekly counts of numbers observed at all seasons of the year, with due allowance for weather and other conditions affecting the counts, Table 18 has been prepared as an attempt to estimate the total bird population present at various times throughout the year. Only the fairly well-known species are included in this list as such. Others are totaled under appropriate headings. Young birds are not counted until they become independent of parents. While the figures are an attempt to approximate the highest population numbers reached each month even this figure is of course not constant during the month.

Food Chains and Ecological Niches

While the numbers of nesting pairs of birds in the area may at first glance seem to crowd the territory unduly, yet competition for food is really limited by reason of the territorial relations of competing species or individuals, and the particular ecological niches in the forest community occupied by others.

The barred owl, the ruffed grouse, and the robin probably do not com-

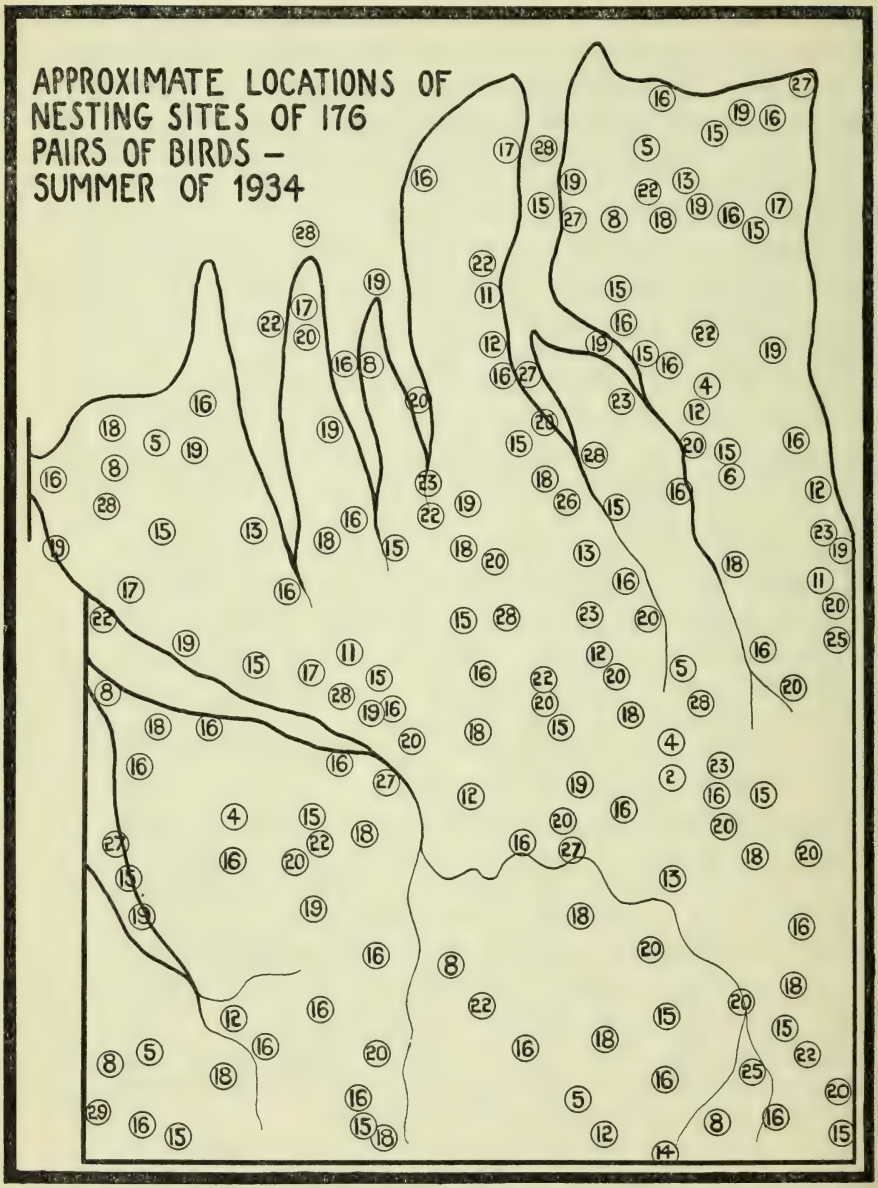

FIG. 15. Approximate locations of nesting sites of breeding birds in Table 17, summer of 1934.

2—Barred owl
4—Hairy woodpecker
5—Downy woodpecker
6—Crested flycatcher
8—Wood pewee
11—Chickadee
12—Tufted titmouse
13—White-breasted nuthatch
14—Robin
15—Wood thrush
16—Red-eyed vireo
17—Black-throated green warbler
18—Oven-bird
19—Hooded warbler
20—Redstart
22—Scarlet tanager
23—Cardinal
25—Towhee
26—Cerulean warbler
27—Acadian flycatcher
28—Yellow-throated vireo
29—Red-bellied woodpecker

Table 18. Estimated average bird population by months based on 1932, 1933, 1934, and 1935 figures.

	March	April	May	June	July	August	September	October	November	December	January	February
Permanent residents:												
Tufted Titmouse	20	20	14	14	12	12	12	20	20	20	20	20
Eastern Cardinal	10	10	10	10	10	10	10	10	10	10	10	10
White-breasted Nuthatch	16	16	10	6	6	6	12	12	30	20	16	16
Black-capped Chickadee	16	16	8	8	8	8	16	16	16	16	16	16
Northern Downy Woodpecker	16	16	8	6	6	6	10	10	16	16	16	16
Eastern Hairy Woodpecker	6	4	4	4	4	4	8	8	8	8	6	6
Red-eyed Towhee	10	10	10	4	4	4	4	4	10	10	10	10
Northern Barred Owl	2	2	2	2	2	2	2	2	2	2	2	2
Northern Pileated Woodpecker	2	2	2	0	0	0	2	2	2	2	2	2
Red-bellied Woodpecker	1	1	0	0	0	0	1	1	1	1	1	1
Eastern Ruffed Grouse	1	1	1	0	0	0	0	1	1	1	1	1
Totals	100	98	69	54	52	52	78	86	116	106	102	100
Summer residents:												
Red-eyed Vireo	....	....	82	62	50	30	20	....	....	....	....	....
Wood Thrush	....	....	54	38	32	20	10	2	....	....	....	....
American Redstart	....	....	50	34	16	8	....	....	....	....	....	....
Hooded Warbler	....	....	28	28	20	14	10	1	....	....	....	....
Oven-bird	....	....	40	26	14	8	6	5	....	....	....	....
Scarlet Tanager	....	....	16	16	12	8	4	....	....	....	....	....
Eastern Wood Pewee	....	....	10	14	14	10	6	....	....	....	....	....
Yellow-throated Vireo	....	....	10	8	6	2	2	....	....	....	....	....
Acadian Flycatcher	....	....	6	6	4	4	4	....	....	....	....	....
Black-throated Green Warbler	....	10	25	6	6	2	30	2	....	....	....	....
Eastern Cowbird	....	2	4	6	....	....	....	....	....	....	....	....
Cerulean Warbler	....	....	20	2	2	2	2	....	....	....	....	....
Northern Crested Flycatcher	....	....	4	2	2	2	1	....	....	....	....	....
Louisiana Water Thrush	....	4	10	2	2	2	....	....	....	....	....	....
Eastern Phoebe	....	....	4	2	2	2	....	....	....	....	....	....
Eastern Robin	....	6	2	2	2	10	100	500	250	2	2	2
Totals	....	22	365	254	184	124	195	510	250	2	2	2
Autumn and winter visitors, transients and occasionals												
Autumn and winter visitors	20	30	10	....	....	....	25	75	50	30	10	10
Red-breasted Nuthatch	20	40	15	....	....	....	10	60	75	50	30	25
Slate-colored Junco	50	50	....	....	....	....	....	50	50	25	10	5
Transient Warblers	....	10	300	....	....	15	150	50	....	....	....	....
Eastern Hermit Thrush	....	30	....	....	....	....	....	50	....	....	....	....
Olive-backed Thrush	....	....	75	....	....	....	50	75	....	....	....	....
Gray-cheeked Thrush	....	....	10	....	....	....	10	....	....	....	....	....
Wilson's Thrush	....	....	25	....	....	....	10	15	....	....	....	....
White-throated and Fox Sparrows	....	20	50	....	....	....	10	75	10	....	....	....
Occasional visitors	15	20	20	5	5	20	30	15	10	5	....	15
Totals	105	200	505	5	5	35	295	465	196	110	50	55
Grand Total	205	320	939	313	241	211	568	1061	562	218	154	157

pete with any other species for food. The woodpeckers, while all seeking their food in the same way, probably overlap very little, as the different species work upon different parts of the larger trees, and the downy pays a

good deal of attention to lesser growth, not worked by the other larger birds. While the 3 pairs of white-breasted nuthatches may sometimes come into competition with the downy woodpeckers, their nesting sites are widely separated so that competition is reduced to a minimum. The nuthatches may come into real competition with the chickadees and titmice, but this combination represents but 18 pairs of birds at its recorded maximum during the nesting season, which allows 3.6 acres (1.45 hectares) to the pair if the territory were evenly divided between them. As a matter of fact the chickadee and titmouse nesting territories seem to be complementary to each other, while the nuthatches cover a much wider range than either of the others.

So far as food habits are concerned the flycatchers form a group by themselves, each species having its own special hunting ground. The crested flycatcher pairs keep strictly to its part of the woods. The Acadians each have their own little glen, with a stream running through it, and no other flycatchers in the vicinity. The wood pewees have widely separated territories of their own in the higher levels of the forest. The hooded warblers and the redstarts may compete at times with each other, yet in a general way they are somewhat complementary as the redstart usually hunts in higher territory than does the hooded warbler.

The birds whose food habits call them frequently or almost entirely to the ground in summer—the Louisiana water thrush, oven-bird, wood thrush, cardinal, towhee—have about 2 acres (0.8 hectares) per pair on the average, which would furnish them with plenty of food supplies not drawn upon to any extent by other species.

This reserves the leafy foliage of the forest trees to the tanagers, vireos, and cerulean warblers—not entirely, of course, but this is their particular niche. The black-throated green warblers seem to keep pretty closely to the upper parts of the large hemlock trees during the nesting season, and their nesting sites are widely separated.

So far as factors within the environment are concerned this summer population of breeding birds seems to be regulated largely in its distribution and density within the area by the available food supplies, and the number and fitness of nesting sites and ecological niches offered by the forest environment.

It is difficult, if not impossible, to assign places of relative influence to particular species of birds inhabiting the community. In the aggregate the birds consume an immense amount of insect food as well as considerable vegetable matter. Certain groups, however, may be singled out as of outstanding importance because of numbers, or because of their constant activity throughout the year.

Probably the most influential of these groups is that composed of the

hairy and downy woodpeckers, chickadee, tufted titmouse, and white-breasted nuthatch. These are all permanent resident species, and their numbers are considerably increased at certain times of the year. They constitute a company of very diligent searchers after insects on and under the bark of trees, and in dead wood, dividing between them the territory to be covered, so that very little tree surface escapes their attention. Larvae of beetles and other insects, eggs, pupating insects, hibernating insects, spiders, myriapods, and others form the bulk of their diet. Beech nuts are eaten by all of these species as well as many wild fruits. Their limited range keeps them within the area, and thus entirely dependent upon it for their food supplies.

There is no doubt but that the heaviest summer influence is exercised by the group composed of wood thrush, oven-bird, hooded warbler, red-eyed vireo, redstart, and scarlet tanager. All these are highly insectivorous. They cover all levels from ground to tree-tops, and so serve as an efficient check to the summer insect population. Yet their stay in the area is limited, and their activities are spread over too short a space of time to give them first rank in influence. They supplement the activities of the first group when the insect tide is rising to its greatest proportions, and it may be questioned whether, in the absence of either group the forest could long continue to maintain itself. It is of interest to note how, in August, the chimney swifts and purple martins, hunting immediately above the forest roof, complete the occupation of all levels in the community of forest animals.

Another great bird group is that composed of robins, hermit thrushes, and olive-backed thrushes in autumn. Although these birds come mainly for forest fruits, among which the wild grape ranks high, they also spend much time raking over the dead leaves of the forest floor for insect food. Of great importance also is the frequently large group of migrating warblers in spring. Though their stay in the area is brief, they rid the developing foliage and bark surfaces of the trees of many newly hatched insects before the minute larvae have developed into larger consumers of foliage.

The most important non-breeding bird in the area is the red-breasted nuthatch. Though present only in alternate winters during the period of this study, and though their numbers are marked by considerable fluctuation, they often surpass in numbers all other species put together. Their length of stay covers a period of over seven months, and while present they are apparently strictly resident. They are very diligent in their pursuit of food, spending much time searching the bark, limbs, twigs, and decayed places of the forest trees. Beech nuts are taken with evident relish. The red-breasts work all the way from the ground to the tops of the highest trees, and do not hesitate to enter the cavities of decaying logs.

The barred owl and the pileated woodpecker stand out because of their size and year-round activity. The woodpecker's range is much larger

than the area under study, and though a single pair, sometimes augmented by young in summer, or another presumably immature bird in winter, spend much time in the area, they are not dependent upon it for their living. Their work on hemlock trees infested by the bark-boring beetle is very evident. They also do much work in digging for grubs and ants in trees like the white ash, in which the heart-wood is decayed, but the sap-wood is still sound. The pileated woodpecker is an influential bird in the area, but important in a supplementary way rather than primarily. On the other hand, the barred owl is more nearly resident, probably not going far beyond the limits of the area on his hunting trips. In summer the single pair of owls breeding in the beech-maple association seem to hold themselves and their young quite closely to the interior forest, appearing to be entirely dependent upon it for food supplies.

That short-tailed shrews form the bulk of the owl's diet is very apparent. The barred owl has frequently been observed in the act of catching these little animals, and no cast pellet so far examined has failed to include jaws or skulls of from 1 to 4 shrews *(Blarina brevicauda)*. Remains of the white-footed mouse are also frequently found, but not always, as is the case with the shrew. Though these two animals probably make up most of the barred owl's diet, the writer is inclined to the opinion that a considerable number of the smaller insectivorous birds are also consumed, especially in early spring when the summer resident bird population is concentrating its activities upon the incubation of eggs and rearing of young. The frequently deserted and destroyed nests found at this season strongly suggest that the incubating or brooding bird has come within range of the owl's telescopic vision, and has been picked off—sometimes nest and all. When the owl's nesting site was examined in April 1932, after the young had come off, feathers of hairy woodpecker, red-bellied woodpecker, blue jay, cedar waxwing (*Bombycilla cedrorum* Vieillot), bob-white, and horned lark (*Otocoris alpestris* Linn.) were recovered from the débris at the bottom of the nesting cavity. The presence of horned lark feathers certainly indicates an excursion into the open fields outside the woods, and the bob-white and cedar waxwing remains are corroborative evidence of the same thing. The barred owl therefore is of large importance in the community as a check upon the numbers of shrews and mice, and to a much less extent as a limiting influence on the reproduction of smaller birds within the area.

It is more difficult to classify the birds of the area on the basis of food habits than it is the mammals. The barred owl is the only one among the permanent residents to be classed as a carnivore. Yet he is also an eater of insects (Fisher 1880). The other permanent residents, while all consuming considerable vegetable matter, particularly beech nuts, could probably, with the possible exception of the ruffed grouse, get along quite well in

the absence of vegetable provender. The summer residents are predominantly insectivorous—the flycatchers, warblers, vireos, and tanager completely so (Forbush 1927, 1929). Thus it appears that the bird population of the area, with the exception of the barred owl, is supported mainly by the insect food supplies of the forest, and only secondarily, and to a much less extent, by plant products.

Seasonal Changes in the Bird Population of the Area

One of the main characteristics of the bird population of the area under study is its instability. Fluctuations in numbers are at times extreme, and even in winter numbers are far from constant. While the total of species listed is 83 (Table 16), only 11 of these are classed as permanent residents. Even the summer nesting species constitute a rapidly shifting element in the total bird population. What the increase in numbers may be when young birds are launched upon independent careers is largely a matter of conjecture, for it is certain that most of the summer resident species leave the area with their young as soon as the latter are capable of sustained flight. One must also allow for a large mortality among both young and old, and must count upon a large percentage of failures of nesting pairs to bring any young birds off the nest. Butts (1930), working with banded white-breasted nuthatches, noted the frequent disappearance of apparently permanent resident birds. Out of 21 individuals, 10 disappeared in two years, and only one, banded at the beginning of his study, lasted throughout the three years of its duration. Probably the length of life of most small birds is not more than two years on the average. The probability is that when the summer is over, the net increase in the bird population is not large. Depletions from the ranks of the older birds are made good by the entrance of younger birds into the community, perhaps in numbers just large enough to absorb the losses that are due to come as a result of autumn and winter casualties, and so maintain the species at about its normal numbers.

Reference to Table 18 will give an idea of constantly changing numbers, but when this is reduced to diagrammatic form (Fig. 16) the often extreme and abrupt fluctuations as well as the more gradual changes in the bird population of the area are clearly apparent. As the red-breasted nuthatch has been present only on alternate years, this species is set off from the other winter visitors.

It is in the spring and autumn that the fluctuations in number of birds in the area are relatively enormous. During the first half of the month of May the woods are flooded with migrant species on their way to more northerly breeding grounds. At the same time the greater number of the summer resident species are arriving. In October and November the woods are again filled with large numbers of robins and flocks of migrating thrushes

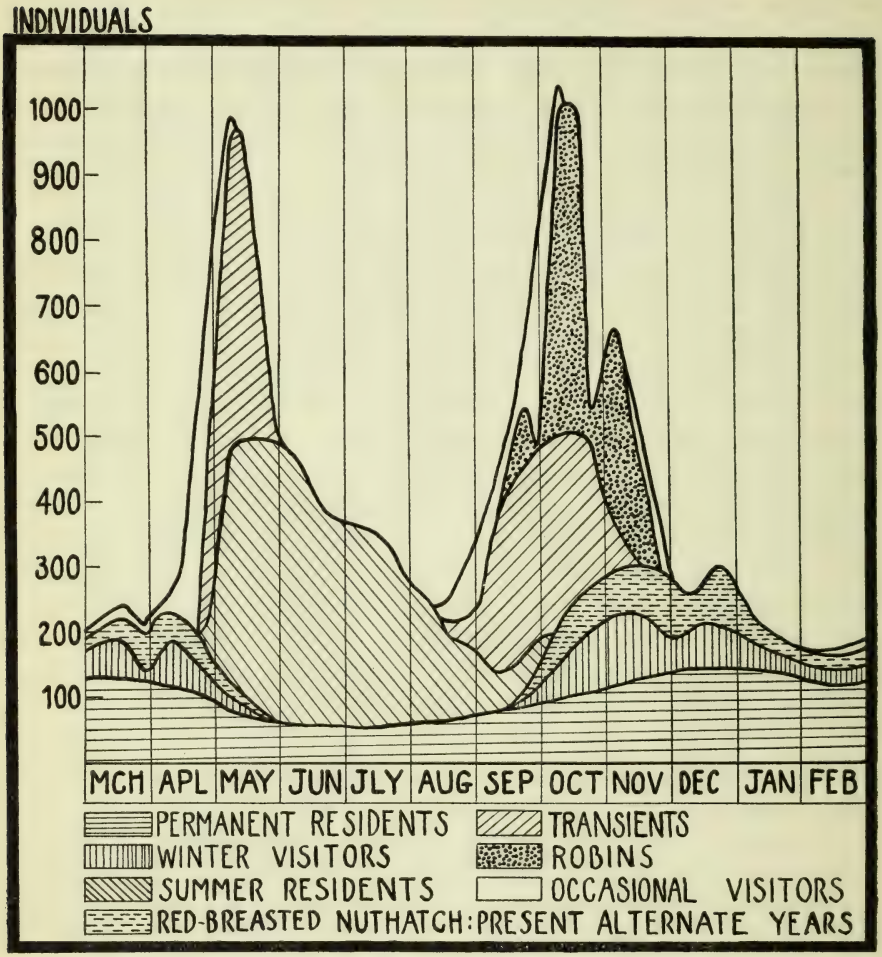

FIG. 16. Seasonal fluctuations in the bird population of the area under study on the basis of estimates and averages of weekly counts for 1932, 1933, and 1934.

and sparrows. The winter visitors are already well massed in October and reach a peak of numbers in November. These two months witness the largest assemblage of birds in the area during the year. The two periods of least numbers are the second week in August, when the summer population is depleted, and the last week in January, when many of the winter visitors have left the area and the influence of the northward movement is so soon to come is not yet evident.

THE REPTILES OF THE AREA

During the first two and a half years of this study the only reptiles observed in the area were snakes. In the spring of 1934 Mr. M. B. Walters

and the writer together were fortunate enough to get very good sight records of several five-lined skinks, thus adding a lizard to the list. The reptiles thus far observed, specimens of all of which except the skink have been collected, are shown in Table 19. Scientific names are as used by Ditmars (1920).

Table 19. Reptiles of the area.

Five-lined Skink	*Eumeces quinquelineatus* (Linn.).
Ribbon Snake	*Eutaenia saurita* (Linn.).
Common Garter Snake	*Eutaenia sirtalis* (Linn.).
Common Water Snake	*Tropidonotus fasciatus sipedon* (Linn.).
De Kay's Snake	*Storeria dekayi* (Holbrook).
Red-bellied Snake	*Storeria occipitomaculata* (Storer).
Pilot Blacksnake	*Coluber obsoletus* (Say).
Milk Snake	*Ophibolus doliatus triangulus* (Daudin).

The skinks were observed on May 7, 1934, running in and out from under the loose bark on a large fallen beech log, evidently enjoying the brilliant spring sunshine which was a feature of that day. Three were seen at one time and two at another, but the total number may not have been more than three. One of these was in the "blue-tailed" stage, the others brown, with characteristic red heads. As this is the only recorded occurrence of these animals in the area their numbers must be few.

The common garter snake and the ribbon snake, while regularly found, are not abundant. Five small immature common water snakes have been taken in or near the course of the main stream bed in the area. This species is common in a pond about a half mile west of the area, and these young snakes may possibly have come into the woods from that direction. Three specimens only of the milk snake have been taken. Five fine examples of the red-bellied snake have been found, one of which, while in temporary captivity, gave birth to 21 living young. The period of activity of these snakes is from about May 1 to the latter part of October.

The only reptile inhabiting the area that can be said to be present in numbers is the pilot blacksnake. During the summer of 1931 12 or 13 of these beautiful serpents were taken in the area. Most of these were over 4 feet (121.9 cm.) in length; several were over 5 feet (152.4 cm.); and the cast "skin" of one has been found measuring 6 feet 1 inch (185.3 cm).

After several days in captivity the pilot blacksnake can be handled easily. Captive specimens have proved to be remarkably expert in climbing, and exceedingly muscular in action. According to Ditmars (1920), the snakes of the genus *Coluber,* to which the pilot blacksnake belongs, feed upon warm-blooded prey exclusively—especially the smaller rodents—and also upon birds and their eggs. One is mentioned as having disgorged a well-grown cottontail rabbit upon being captured. Captive snakes of this species, observed by the writer, took three young scarlet tanagers which were found dead, their nest having been blown down in a storm. One was reported as

having been seen coiled about a wood thrush's nest some 20 feet (6 meters) above the ground in a young sugar maple sapling, having apparently made a meal of the young birds.

When released, these snakes quickly disappear beneath the leaf litter, or into any near-by cavity under a log or stump. One can easily see what an efficient hunter of chipmunks, mice, shrews, and young birds an animal of this sort might be.

The earliest record of the appearance of the pilot blacksnake in spring in the area is May 2. On this date the writer saw a fine specimen which when measured later proved to be 4.5 feet (137.1 cm.) in length. There was considerable soil adhering to the reptile's back, as though he might have just emerged from an underground retreat. He was lethargic, allowing the camera tripod to be set up within a few inches of his head, and when picked up showed no signs of fight, which is unusual in this species. The inference was that he had just emerged from hibernation. As these snakes disappear in October, this allows for a full six months period of activity.

As to the rate of reproduction of the pilot blacksnake, one captive specimen, 5 feet 4 inches (162.5 cm.) long deposited 22 eggs on July 18. Several days later, another of lesser length laid 13 eggs.

The pilot blacksnake is well distributed throughout the area, having been observed in all parts of it, including beech-hemlock environment. During the past three years 10 of these snakes have been marked by making a deep V-shaped nick in the outer edge of one of the ventral plates, and then have been set at liberty. The number of the marked plate, counting from the anus has been recorded in each case, being a different number for each snake. One of these, marked in the summer of 1932, was recovered near the point of original capture and set at liberty again May 6, 1934. This would seem to indicate a rather closely resident character for these serpents. The numbers of pilot blacksnakes, judging from captures made, seemed to be fairly constant in 1932 and 1933, but were distinctly less in 1934 and 1935. This is apparently correlated with the falling off in numbers of small mammals in 1933 and 1934.

The importance of the garter snake, ribbon snake, and water snake in the area seems relatively very small because of their insignificant numbers, small size, and food habits which restrict them to insects, worms, frogs, and toads. If the milk snake should be found here in numbers, it would need to be classed as an important member of the community, but at present there is no evidence that this is the case. The red-bellied and De Kay's snakes may be present in greater numbers than the few records indicate. They are secretive in habits, and normally not often seen. Ditmars (1920) says that the food of these snakes consists of earthworms, slugs, and the soft-bodied grubs of beetles. Their burrowing habits might make them

important insect hunters in decaying stubs and logs. If present in numbers they would therefore be important members of the forest community.

The pilot blacksnake must be classed as among the really important members of the community. In size, in numbers, in food habits, in rate of reproduction, and in activity it ranks well up among the more important animals of the area.

The Amphibia of the Area

The list of amphibians thus far discovered in the area is shown in Table 20.

Table 20. Amphibia of the area.

Toads and frogs	
American Toad	*Bufo americanus* Le Conte.
Fowler's Toad	*Bufo fowleri* Putnam.
Pickering's Hyla	*Hyla crucifer* Wied.
Green Frog	*Rana clamitans* Latreille.
Eastern Wood Frog	*Rana sylvatica* Le Conte.
Salamanders	
Brown Salamander	*Desmognathus ochrophaea* Cope.
Dusky Salamander	*Desmognathus fusca* (Rafinesque).
Spotted Salamander	*Ambystoma punctatum* (Linn.).
Mole Salamander	*Ambystoma talpoideum* (Holbrook).
Red-backed Salamander	*Plethodon cinereus* (Green).
Slimy Salamander	*Plethodon glutinosus* (Green).
Red Eft	*Triturus viridescens* Rafinesque.

Toads and frogs are not abundant in this forest community. But 3 records of the American toad, and 5 of Fowler's toad have been made. The wood frog and Pickering's hyla occur more frequently but have never been observed in numbers. Each is generally distributed throughout the area, but more often encountered on the lower levels than on the higher land. During the summers of 1931 and 1932 the green frog was the common frog of the area. Nearly every pool of standing water had its one or more small half-grown frog of this species. During dry weather they would disappear, but after a rain would appear again. In 1933 green frogs were scarce in the area, and in 1934 and 1935 they were completely absent. After the dry summer of 1933 all frogs became exceedingly scarce in the area.

Nor are salamanders abundant. The commonest species is *Triturus viridescens* in the second larval form commonly known as the "red eft." The adult form is very common in a pond to the west of the area. After a rain in summer these brilliant red salamanders may be seen walking abroad quite fearlessly. The writer has seen both the raccoon and the crow refuse to eat the red eft, though they would take salamanders of other species. Perhaps this matter of being unpalatable may account for the somewhat greater abundance and lack of fear of this species. The dusky salamander is quite abundant in certain wet places under stones in stream beds. The red-backed and brown salamanders are both found sparingly under logs and bark or in moist dead wood. The slimy salamander seems to be

rather generally distributed through both associations, but quite sparingly, while the spotted salamander and the mole salamander are rare. After the very dry summer of 1933 all salamanders became quite rare in the area, the red eft being the only species that seems to have escaped a drastic reduction in numbers.

Not much can be said at this time as to the relative importance of amphibia in the area. That frogs are an item in the fare of the raccoon may be infered from the abundance of the raccoon tracks about the places where frogs are to be found. Doubtless most of the other amphibians, when encountered, would be added to the raccoon's diet. The same would hold true for the skunk and the opossum, and doubtless for other mammals and some birds. The ribbon snake, the garter snake, and the water snake are known to be addicted to amphibian fare (Ditmars 1920).

On the other hand the toads, frogs, and salamanders fill a definite niche in the economy of the forest as large consumers of insects, slugs, and larvae. Yet because of their small numbers in the area under study they do not seem to be of great importance to the community as a whole.

INVERTEBRATES OF THE AREA

The molluscs listed in Table 21 have all been collected as live animals within the area and the dead shells of many of them are quite common on chipmunk feeding tables and in shrew runways.

TABLE 21. Molluscs of the area.

Polygyra stenotrema (Ferussac).	*Polygyra fraterna* (Say).
Polygyra tridentata (Say).	*Omphalina inornata* (Say).
Polygyra fraudulenta (Pilsb.).	*Omphalina fuliginosa* (Griffith)
Polygyra albolabris (Say).	*Anguispira alternata* (Say).
Polygyra albolabris dentata Tyron.	*Succinea retusa* Lea.
Polygyra thyroides (Say).	*Succinea ovalis* Say.
Polygyra clausa (Say).	*Circinaria concava* (Say).
Polygyra zaleta (Binney).	*Vitrea hammonis* (Ström.)
Polygyra palliata (Say).	*Zonitoides minuscula* (Binney).
Polygyra hirsuta (Say).	*Limax maximus* Linnaeus.

Cahn and Kemp (1929) mention finding the shells of *Anguispira alternata* and *Polygyra stenotrema* in nests of the white-footed mouse. Shull (1907) found that in winter, snails of the genus *Polygyra (albolabris, multilineata, profunda, thyroides, fraterna)* formed much of the food supply of the short-tailed shrew. That land snails are preyed upon by certain beetles and their larvae is also established (Lengerken 1934, Boettger 1934). Boycott (1934) says that competition between land snails is an almost negligible factor, and that there is no specific relation between Mollusca and trees.

The crayfish *Cambarus bartoni robustus* Girard is common in the main stream bed of the area. Crayfish are said to be fed upon by raccoons, salamanders, frogs, birds, snakes, turtles, and fishes (Turner 1926). The same

author says that crayfish are generally omnivorous, eating almost anything of an organic nature that comes to hand, whether of animal or vegetable material.

The temporary pools in the beech-maple association were studied in the spring of 1933 by Dr. Norma C. Furtos. During this study the temperature of the water varied from 40° C. (39.2° F.) on April 8 to 15° C. (59.° F.) on April 28. Organisms found are listed in Table 22.

Table 22. Organisms in temporary pools.

Arcella sp.
Trachelomonas sp.

Planaria velata Stringer. (common)

Alona guttata.
Chydorus sphaericus (O. P. Müller).
Cyclops viridis Jurine.
Cyclops crassicaudis Sars.
Cyclops serrulatus Fischer.
Cyclops bicuspidatus Claus.
Canthocamptus staphylinoides (Jurine).
Candona decora Furtos.
Candona brevis Muller.
Eucypris sp.
Eucypris fuscata (Jurine) var. *gigantea* Furtos.
Eucypris sp.
Cypricercus tincta Furtos.
Cryptocandona sp.

Gammarus sp.
Eucrangonyx Sp.
Macrobiotus sp.

In addition to the species listed (Table 22) aquatic earthworms were commonly found, a small crayfish was taken, and larvae of caddis fly, mayfly, *Diptera* and *Coleoptera,* were found to be common. Mosquito larvae were very abundant. Red water mites were common.

Obviously no complete understanding of the dynamics of the forest can be secured without a thorough study of its insect life. This should be done quantitatively as well as qualitatively. On all sides the evidences of the activities of wood-boring and bark-boring insects are apparent. There are bees and flies and wasps and butterflies and small midges and mosquitoes in the air. Moths large and small are common. The big syrphid fly *Milesia virginiensis* Dru. is common, as are the scavenger beetles *Necrophorus marginatus* Fab. Camel crickets are abundant in the humus in certain places. Ground beetles are abundant everywhere. The yellow-jacket *Vespa communis* De S. and the white-faced hornet *Vespula maculata* (Linn.) are very common. The writer counted 9 large nests of the latter species in the winter of 1934-35 in the area. The work of the flat-headed hemlock borer *Melanophila fulvoguttata* Harr. is very noticeable in the beech-hemlock areas. The fungi of the area support a numerous insect population. In September the white woolly aphid *Schizoneura imbricator* Fitch. is often noted on the branches of the beech. Various kinds of caterpillers are noted on the foliage of the trees, and vireos and warblers seem to find much to glean from foliage beyond the range of one's vision. In August and September the hum of insects is a definite feature of the forest.

By reason of their numbers, their destructive activities from the standpoint of plant life, their rôle as reducing agents in dead and decaying tim-

ber, their interrelations within their own group, their relations to other animals as parasites, and their great importance as a source of food supply, insects occupy a place of great significance in the biotic community. While their importance is recognized, it is impossible here to do more than call attention to it.

ECOLOGICAL CLASSIFICATION OF ANIMALS

The study of animal ecology has not as yet developed a commonly accepted terminology. As that suggested by Smith (1928) does not seem to the writer to be entirely adequate to some of the situations arising in this study, the following special terms are herein employed:

1. Predominants are those animals which are most abundant in numbers and of greatest influence in the community.

2. Members are those animals that are present in smaller numbers than predominants, and therefore of lesser influence. The term may be applied to a single individual.

Both predominants and members may be further subdivided by employing the following adjectives.

1. Permanent. Used to indicate constant presence and activity throughout the year.

2. Fluctuating. Used to indicate marked lack of constancy in numbers and activity at different seasons, although present throughout the year.

3. Seasonal. Used to indicate presence or activity at one or more seasons of the year and entire absence or inactivity at others.

4. Incidental. Used to indicate irregular and inconsequential occurrence in the community.

TABLE 23. Ecological classification of vertebrates in the beech-maple association.

Predominants	Members
Permanent predominants	Permanent members
Mammals	Mammals
Short-tailed Shrew	Eastern Red Fox
Northern White-footed Mouse	New York Weasel
	Southern Red Squirrel
	Small Eastern Flying Squirrel
	Domestic Dog
	Domestic Cat
Birds	Birds
Eastern Hairy Woodpecker	Eastern Ruffed Grouse
Northern Downy Woodpecker	Northern Barred Owl
Black-capped Chickadee	Northern Pileated Woodpecker
Tufted Titmouse	Red-bellied Woodpecker
White-breasted Nuthatch	Eastern Cardinal
Fluctuating predominants	Fluctuating members
Mammals	Mammals
Northern Gray Squirrel	Cottontail Rabbit
Eastern Chipmunk	Smoky Shrew
Pine Mouse	
Birds	Birds
Eastern Robin	none

Seasonal predominants	Seasonal members
Mammals	Mammals
none	Virginia Opossum
	Eastern Raccoon
	Eastern Skunk
	Southern Woodchuck
	Big Brown Bat
Birds	Birds
(nesting species	(nesting species)
Red-eyed Vireo	Crested Flycaster
Wood Thrush	Acadian Flycaster
Hooded Warbler	Eastern Phoebe
American Redstart	Yellow-throated Vireo
Oven-bird	Cerulean Warbler
Eastern Wood Pewee	Louisiana Water Thrush
Scarlet Tanager	Rose-breasted Grosbeak
	Red-eyed Towhee
(transient species)	(transient series)
Eastern Hermit Thrush	American Woodcock
Olive-backed Thrush	Yellow-bellied Flycatcher
	Winter Wren
	Gray-cheeked Thrush
	Wilson's Thrush
	Eastern Golden-crowned Kinglet
	Eastern Ruby-crowned Kinglet
	Blue-headed Vireo
	Black and White Warbler
	Blue-winged Warbler
	Nashville Warbler
	Magnolia Warbler
	Black-throated Blue Warbler
	Blackburnian Warbler
	Chestnut-sided Warbler
	Blackpoll Warbler
	Connecticut Warbler
	Canada Warbler
	Purple Finch
	White-throated Sparrow
	Fox Sparrow
	Yellow-bellied Sapsucker
(winter resident species)	(winter resident species)
Red-breasted Nuthatch	Eastern Goldfinch
Reptiles	Reptiles
Pilot Blacksnake	Five-lined Skink
	Ribbon Snake
	Garter Snake
	Red-bellied Snake
	De Kay's Snake
	Milk Snake
Amphibians	Amphibians
Green Frog	American Toad
Wood Frog	Fowler's Toad
Pickering's Hyla	
	Dusky Salamander
Red Eft	Brown Salamander
Red-backed Salamander	Slimy Salamander

Incidental Members

Mammals

Fox Squirrel	Hairy-tailed Mole
Meadow Mouse	Red Bat
Star-nosed Mole	Silver-haired Bat

Birds

Turkey Vulture
Sharp-shinned Hawk
Cooper's Hawk
Eastern Red-tailed Hawk
Broad-winged Hawk
Eastern Bob-white
Eastern Mourning Dove
Yellow-billed Cuckoo
Great Horned Owl
Eastern House Wren
Eastern Nighthawk
Chimney Swift
Ruby-throated Hummingbird
Northern Flicker
Northern Blue Jay
Purple Martin
Eastern Crow
Starling
Brown Creeper
Carolina Wren
Bronzed Grackle
Eastern Cowbird
Eastern Blue Grosbeak
Indigo Bunting
Common Redpoll
Red Crossbill
Slate-colored Junco
Eastern Whip-poor-will

Reptiles

Common Water Snake

Amphibians

Spotted Salamander
Mole Salamander

ASPECTION

Aspection, or phenology, has to do with the visible evidence of the responses which plants and animals make to the changing of the seasons. It is usual to divide the year on the basis of plant activity into six main periods, or aspects; the prevernal, vernal, aestival, serotinal, autumnal, and hibernal (McDougall 1927, Weaver and Clements 1929). While this has been adopted also for animals as a convenient way of designating seasonal changes, it is difficult to assign time limits to any of these divisions since one merges insensibly into another. In discussing fluctuations in abundance of mammals, birds, and other animals in the community under study, reference has been made to certain seasonal changes in numbers. These also constitute parts of seasonal aspects.

The main changes to be noted in the aspect of the forest composing the beech-maple association at North Chagrin are somewhat as follows:

1. *Prevernal aspect.* Although February is usually the coldest month of the year (Fig. 3) and most of its aspects are hibernal, yet in this month mosses and lichens definitely take on new color, and during the latter part of the month, crows and hawks appear. Tufted titmice and cardinals begin to whistle occasional spring-like notes, and the pileated woodpecker becomes noisy. The woods are very wet from melting snow or rains, and standing water in pools is a feature of the aspect.

By the first week in March some of the plants that have carried green leaves over winter, like spring cress and wild blue phlox, or some of the violets, show definite responses in the erection of their stems and leaves, while the green leaves of wintergreen, partridgeberry and trailing arbutus take on new freshness. Although there is much alternation of freezing and thawing during the month the development of herbaceous vegetation is only temporarily checked by low temperatures, and responds rapidly to increasing warmth. Beech nuts and sugar maple seeds sprout in March even though they are bound to be covered with snow or encased in ice before the month is out.

By the latter part of March hepaticas and spring beauties may be found

in bloom—the hepaticas on certain south-facing slopes, and the spring beauties on the less wet places of the higher portions of the area. Certain species of mosses and lichens will be developing their fruiting bodies. *Protococcus* on beech trunks, and the green alga of the temporary pools start new growth. Throughout the month the barred owl has been sitting on her eggs, and both skunk and woodchuck have come out of hibernation. The tracks of raccoons have become common, chipmunks appear in numbers, bird music increases, and woodpeckers indulge in much drumming.

Unless delayed by snow or unduly low temperatures a great change takes place in the aspect of the forest during the latter part of March and the first of April. The higher land begins to green with the developing leaves of yellow adder's tongue, cut-leaved dentaria, and spring cress. Many plants of spring beauty come into bloom but they do not add appreciably to the green of the forest floor as the color of their leaves is more red than green. Many other plants are now recognizable. The spikes of both red and white trillium are emerging, rue anemone is in the "grape" stage, sweet cicely, Canada violet, blue cohosh, early meadow rue, golden seal, wild leek, wild blue phlox, swamp buttercup, and dutchman's breeches may all be recognized by the practiced eye. The heart-shaped cotyledons of seedling jewelweed are thickly scattered in certain locations. Many clumps of hepatica in bloom may be seen in favorable situations. The flower buds of elms and red maples are large and swollen, and gray squirrels begin to cut them down for food. The voice of *Hyla crucifer* is added to the early spring bird music. On the lower levels near the ground are many insects, particularly mosquitoes, small flies, small bees, and larger honey bees. Mourning cloak, question mark, and red admiral butterflies may be seen. The winter bird companies begin to break up.

By the second week in April the greening of the forest floor has progressed considerably. The foliage of spring beauty, spring cress, cut-leaved dentaria, dutchman's breeches, hepatica, and other plants has now definitely occupied the ground. This is the beginning of the "wildflower" display. From April 10 to 15 hepaticas will be at the height of their blooming season, and so quickly does the peak of their blossoming time pass, that one of these days will stand out above others for the abundant display that it offers. Spring beauties will begin to occupy the ground with their pink and white blossoms a few days later. Both these plants close their flower-heads on overcast, rainy, or cloudy days, so that their color pattern on the forest floor may be withdrawn at times. If snow comes, their flowers or leaves will often be seen protruding from the surface of the white blanket. The woods are still wet at this time of year, and standing water continues in the surface pools.

The buds of the forest trees are swelling now and so adding a new note

of color to the upper stories of the woods. Red-berried elder is sprouting vigorously. Fly honeysuckle comes into bloom. The leaves of wild black cherry break from the buds. The round-leaved violet comes into bloom, the flowers appearing before the leaves.

Titmice are constantly calling and woodpeckers drumming. The first of the summer resident birds—the phoebe—may be found about the wet places where insects are on the wing. The temporary pools swarm with minute forms of plant and animal life. As increasingly more sunlight reaches the forest floor through the leafless branches of the trees, differences in humidity as between day and night often become extreme. By the latter part of April yellow adder's tongue reaches a climax of bloom so that certain places are suffused with its yellow color. Red trilliums are now at their best, and some white trilliums are blossoming. Leaves of May apple begin to be noticeable. The breaking of the leaf buds on the trees gives the branches a filmy appearance and the sky begins to be shut out a bit.

The first week in May marks the high tide of the wild-flower display in the beech-maple association. The great white trillium now occupies the center of the stage and many of the less numerous species are in bloom. Spring beauty spreads itself like a pink carpet on the higher lands. The forest floor seems to be fully occupied with herbaceous growth, and sprouting seedlings of beech and sugar maple are recognized by their cotyledons. The buds on the forest trees now begin to break, and on a certain day the air will be filled with the falling bud-scales of beech. When viewed from a distance these opening buds give characteristic color to the forest trees. Brown indicates beech; green, sugar maple; and red, red maple. Both the beech and the sugar maple now come into bloom—the blossoms of the sugar maple imparting to the trees a brilliant yellow-green color in sunlight. Gray squirrels will be noted in the tree tops feeding upon beech blossoms.

This is the time when the summer resident birds appear, and when the woods may be flooded with warblers and other transient species. On the newly developing foliage tiny caterpillars appear, and in the air there is a surge of newly awakened insect life. Permanent resident birds are already nesting.

In the beech-hemlock association the Canada mayflower is the only herbaceous plant that forms a ground cover. Spikes of this plant appear in late April and the flowers begin to open about May 15.

2. *Vernal aspect.* The aspect of the forest is now rapidly changing, due to the unfurling of the leaves on the trees. Those on the lower levels are the first to expand, making a story of green below the tree tops. About the 10th or 11th of May occurs a day when the trees are hazy with the yellow-greens of newly unfolding leaves. During the time of leaf development on the trees the great white trilliums begin to turn pink and then to fade. As

they pass, the floor of the woods again takes on a yellow hue as three species of yellow violets come into their full flowering season. After them comes the time of flowering of wild blue phlox and wild geranium, but these plants are not in sufficient numbers to add much color to the picture. Seedlings of sugar maple and beech now contribute a good deal of green to the floor of the forest as the earlier herbaceous plants disappear. The green of new leaves of hepatica and May apple also add to the green mantle. From now on the flowers of the herbaceous vegetation are of the more inconspicuous types. The elms and the red maples have already shed their seeds.

As the leaves on the larger trees of the forest develop, less and less blue sky can be seen, until there arrives a time in the latter part of May when the fully expanded leaves shut out the sunlight altogether. The woods are now dark, even at mid-day. This is the time when the spring chorus of the chipmunk reaches its crescendo. These animals are very much in evidence as the dense curtain of foliage shuts the arboreal squirrels from view. The poikilotherms—pilot blacksnake, frogs, toads, salamanders, and snails—are now noticeable. The month of May also witnesses the great northward flight of the transient bird group. Warblers will be noted in the woods, and sparrows under the grape tangles and other débris. It is during the first two weeks of May that the summer resident birds are occupying their breeding territories. The woods are vocal now with bird songs. Insects become abundant. The Acadian flycatcher and the wood pewee complete the list of the summer residents. Now comes the great period of nest building and incubation of eggs. The barred owl, nesting earliest of all, has brought off her brood of three young by the last of April, and now they may frequently be located in the twilight as they beg for food. Young hairy woodpeckers become noisy in their nest holes.

May and June are periods of intense activity among the birds of the area and everything seems to be tense with the pressure of the advance of the season. Both permanent and summer resident species, having appropriated their share of the available nesting territory, are absorbed in the task of reproduction and the placing of their young upon a semi-independent footing in the community. Population density of breeding birds and mammals is at its maximum by the middle of June. Territory lines have been strictly drawn until now, but are relaxed as the summer resident birds bring their young off the nests. This change has already taken place in the case of most, if not all, of the permanent residents. Young gray squirrels, red squirrels, and chipmunks are very noticeable. All hibernators are active and migration is at a standstill. Food is abundant, and the amount of insects consumed must be enormous. Predators, with their own young to provide for, are very active. On days when the humidity is high, frogs, salamanders, snails, and slugs may be found. But this climax of activity quickly passes.

Mortality of young is high, and the moving of the summer bird population out of the area begins quickly.

3. *Aestival aspect.* By the 20th of June a change in activities is noticeable, particularly as regards the bird population, as the summer residents begin to move. Of these the redstart is the most hurried in its departure, young and old quitting the area by the end of June, after a stay of but a little over 60 days. A few redstarts will be seen later but these are probably transients or delayed nesters. The oven-birds follow closely upon the heels of the redstarts. The first week in July sees them practically gone. By the end of July the red-eyed vireo and the wood thrush have moved out. Certain pairs of birds, unsuccessful in the first attempt to raise a family, persist through three, or even more trials, thus prolonging the stay of a small portion of their group through July, or even longer. But by August most of the summer residents have gone.

By mid-June many bird songs are shortened or greatly modified, and many species have become quite silent. This is often a period of dry weather. The pools dry up, the withered plants of May apple and cut-leaved dentaria lie yellow and prostrate upon the ground, the green carpet of May is replaced by one of rich brown as the dead leaves of last autumn are exposed except where seedling beeches and maples have taken their stand. What vegetation of herbaceous character remains begins to look tattered and shop-worn. Forest fruits are developing and squirrels are already cutting down the unripe beech nuts, hickory nuts, and acrons. Tupelo is shedding some scarlet leaves. The round-leaved green orchid and the nodding pogonia belong to the aestival aspect of the forest as they come into bloom at this time. Purple martins and chimney swifts, hunting above the forest roof, now testify to the fact that insects are flying overhead in the sunshine. Tufted titmice may be observed shepherding their families noisily about. A cardinal's tail feather on the ground suggests that this is the period of moulting and aestivation, and shortly chipmunks disappear into their underground quarters. Temperatures are high, the cicadas are noisy, "punkies" *(Culicoides)* become very annoying to humans.

4. *Serotinal aspect.* From mid-August to late September the forest seems silent and deserted. Nesting territories are now disregarded and there is apparent a tendency for birds to travel together in groups. Wandering families of nuthatches, titmice, and chickadees are encountered. If there are moist places in the woods the woodcock is liable to be found here. Nests of the paper wasp have now assumed large proportions. As the fruits of tupelo, hemlock, cucumber, and the oaks develop they are prematurely gathered by blue jays, gray squirrels, red squirrels, and chipmunks. Not only is there an immense amount of fruiting and seeding of forest trees, but also of herbaceous plants. Mushrooms become a feature of the aspect, often in

brilliant colors, and miniature forests of beech drops occupy large spaces about the bases of the beeches. Again the chipmunks, now emerging from their period of aestivation, yield to the ecstasy of the spring chorus. The first migrant birds of autumn—certain warblers, and later, the brown creeper and the golden-crowned kinglet—appear. Black-throated green warblers become briefly abundant beyond the numbers of the summer residents as the southward movement of the species as a whole begins. An inspection of Figure 16 will show that this is a period of low bird population numbers with the flow of bird life constricted into a narrow channel. But in September the stream widens and a period of great unrest is ushered in.

5. *Autumnal aspect.* In late September there are chilly days, and the first of the winter visitors among the birds appear. By the first week in October the few lingering hooded warblers and scarlet tanagers have gone, and other summer resident species are probably represented by late migrating individuals only. The first robins and thrushes are noted in the woods—the prophecy of many more to come. October sees great flocks of them—robins in two great waves, the flocks numbering hundreds—and thrushes—hermits first, then olive-backs, veerys, and gray cheeks. They feast upon the wild grapes, the fruits of tupelo, sassafras, pokeweed, and flowering dogwood. They also give the floor of the forest a thorough looking over for beetles, grubs and other insects, as they turn over the dead leaves and dig into the rich humus. Their stay lasts into November, covering the period of the great fall of leaves from the deciduous trees. Meanwhile the winter visitors are increasing in number, and if the red-breasted nuthatch is present, these numbers may reach considerable proportions. The characteristic winter bird companies are now formed and will keep together throughout the winter.

Color in the forest in autumn develops later than it does along the roadsides, and many trees retain their leaves long after the roadside trees are bare. Elm, tulip, and spicebush begin the process by yellowing early. October 10th sees the first splashes of real color inside the forest, though it will be ten days at least before the woods are all red and gold. Robins are noisy, sounding alarms, calling, and occasionally carolling a bit. Chipmunks add to the racket, chippering and clucking everywhere, and are very active about the grape vines. Both red and gray squirrels are vocal. Blue jays are calling, white-throated sparrows singing in the grape tangles, nuthatches signaling from nearby trees. The green leaves of wild ginger are still bright in places where this plant occupies the ground.

By mid-October, though the interior of the forest is still predominantly green, the tops of the trees show yellow, bronze, and red. The tupelos are quite red. By October 27th the leaves are about half off the trees, and now rains and high winds will begin stripping off all those that have loosened

their grip upon the twigs. In the absence of wind the leaves will fall lazily by ones and twos. Sugar maples and beeches are the last to surrender their leaves to the winds and often small beeches will retain their leaves, dead and brown, throughout the winter. These newly fallen leaves make a transitory carpet of red, yellow, and brown on the forest floor. With the falling of the leaves of the primary dominants beech nuts and maple seeds also are shed in large quantities, and storage activities on the part of chipmunks, red squirrels, and gray squirrels becomes a major activity. Numbers of gray squirrels may increase as individuals from outside the area come in attracted by the abundance of food. There is liable to be a full chorus of chipmunk clucking which may be taken up and carried throughout the entire range of woodland as far as the ear can discern it.

The first week in November sees the forest floor first yellow, then changing through bronze to brown. There are large open spaces in the forest roof, and the dark green of hemlocks begins to show in the background as one faces the areas where the beech-hemlock association has its stand. Voices of towhee, nuthatch and junco are characteristic of this period, and bob-whites may come into the deep woods attracted by the beech nut supply. The trees will be bare by the third week in November. This is still a period of great activity among birds and mammals, and there are days when they are very vocal, and when *Hyla crucifer* adds his voice to the chorus.

6. *Hibernal aspect.* There is no sharp demarcation between autumnal and hibernal aspects. Indian summer days may be extended through November, though snow usually comes before the month is well advanced. Tree trunks are now a feature of the aspect, the light gray of beech and the dark brown of sugar maple making a fine contrast. With the coming of the first real snow-blanket the woods present a record of moving animal life written upon its white surface. This is one of the characteristic aspects of winter. At times the tracks of gray squirrels will cover every part of the area. These animals, with red squirrels and chipmunks, will be noted abroad throughout the winter, and will write most of the story on the snow. Tracks of cottontail rabbit, red fox, white-footed mouse, and short-tailed shrew will be commonly seen. This is the time of hibernation for invertebrates and some vertebrates as well. In December, January, and February the species list of birds is restricted to the permanent resident and winter visitor groups, with a massing of numbers in December and a low point in late January.

A feature of the hibernal aspect is made up of the green leaves which a number of plants carry over winter. Prominent among these is the hepatica. Others are foam flower, bishop's cap, wild blue phlox, spring cress, and some violets, together with christmas fern, spinulose wood fern, marginal shield fern, and shining club moss. The sedge *Carex* shows green clumps

throughout the winter along the edges of the ravines. As the winter progresses the débris of stored foods appears where it is dug up and consumed by the squirrels, and one can form a fairly good opinion as to just what foods are mostly depended upon for winter needs.

Winter in the area under study is a period of high humidity, due to the fact that snow does not usually stay upon the ground for any great length of time, and temperatures are frequently above the freezing point. This means much melting of ice and snow and much standing water in pools. The atmosphere is often filled with mist and the snow saturated with water.

PLANTS AND ANIMALS

The fundamental difference between plants and animals is, of course, that plants manufacture their own foods out of elemental substances, while animals do not, but must in the last analysis depend upon the products of plants for their supplies of food. Seasonal behavior on the part of the animal population of a biotic community is thus closely correlated with seasonal changes in plant activities. Aspection, from the standpoint of the animal population is but a shifting of food supplies—a sort of clearing and resetting of the table. On the other hand, in their search for and gathering of food, and through other activities, animals in turn affect plants in various ways.

Seasonal responses of animals to the activities of plants are well illustrated in the present study. Such responses may be direct, as when the animal is directly dependent upon plant materials for food, or indirect, as when the animal is dependent upon other animals for its food. The following sequence of observed events in the area under study is illustrative of such relationships.

With the blossoming of the early wildflowers in April winged insects appear. These are attracted to the pollen and nectar offered by the flowers, and their activities assist in the cross-pollination of the plants. The phoebe (a flycatcher) now comes into the woods, feeding upon the flying insects as an acceptable food supply.

With the swelling of the buds on the forest trees in spring, gray squirrels climb aloft to sample this new offering of food, and such birds as the purple finch and the rose-breasted grosbeak make their appearance as consumers of this plant product.

With the expansion of the leaves on the trees, hatching insect eggs produce a multitude of caterpillers as consumers of new foliage. With the appearance of this new food supply for birds, come hosts of migrating warblers whose arrival is neatly timed to coincide with the opportunity to glean many of these minute larvae from the developing foliage. The summer resident birds, all highly insectivorous, now arrive from their southern winter-

ing quarters and replace the early transients as consumers of enormous numbers of insects.

With the storage of carbohydrates in roots, tubers, and other underground structures of herbaceous plants, chipmunks begin to nose the ground and to plow up many of these crisp foods. They also feed upon blossoms and developing seeds.

With the ripening of forest fruits, birds and rodents become very active about the bearing trees and vines and lesser growth as they feast upon these newly offered foods.

With the development of the great forest crop of gilled mushrooms, a new assembly of insects becomes active as a consumer of this plant product, and many rodents also seek it out as a new food.

With the falling of nuts and seeds from the trees, activity on the part of mice and squirrels becomes strenuous as they gather these staple foods for storage against future needs.

With the arrival of winter inactivity in the plant world the animal population exhibits a number of differing responses to this radical change in conditions. Some species migrate to other places, some go into hibernation, some live upon the stored food which they have gathered and laid away, some increase their resistance to lowered temperatures and go on hunting as before.

Basically the forest dominants must be considered as the determiners of the whole complex of life within the range of their influence. They, of course, depend upon soil and climate for their existence where they are, but being there, they not only *limit* and *circumscribe* the life activities of other organisms associated with them, but *vitalize* them as well. The limiting influence of the forest on other organisms is expressed through such things as occupation of the ground, cutting down of light, increasing relative humidity, reducing rate of evaporation, modifying temperature—matters which in the present study have been considered under the head of climate. Species which are not equipped to live in such an environment are excluded. The vitalizing influence of the forest is expressed through the production of stored energy of such quality and quantity, and in such form, as to be readily available to the animal population as food.

The beech-maple forest thus limits and supports an enormous insect population which not only consumes vast amounts of plant material, but which also has many complex interrelations within its own group and with other animals; a rodent population adapted to the use of beech nuts and sugar maple seeds; a shrew population that spreads its network of tunnels beneath the humus for the capture of insects and other prey; a woodpecker-nuthatch-flycatcher-thrush population adapted to the capture of insects in many different situations above ground; and a relatively small carnivore

group which subsists upon the smaller vertebrates. The mammals are predominantly seed and insect eaters, the birds predominantly insectivorous. Chains of animals are thus linked together by food, and all dependent in the long run on plants. Thus we have the concept of the food chain and the food cycle (Elton 1927).

In addition to an adequate food supply, the numbers of animals to be found within a forest community are greatly influenced by the facilities offered for successful reproduction and for protection from enemies. From the standpoint of birds and mammals this means cover, nesting sites, nesting materials, and satisfactory adjustment to the environment during the breeding season. It is because the forest under study is rich in these respects that such a large animal population as has been noted at times is possible.

From the standpoint of the effects of animal activities upon plant life the fact of outstanding significance is the very large consumption of plant materials by insects. Not only is the steady consumption of foliage by the larvae of many species involved, but no part of the plant structure is immune from attack. Buds, leaves, blossoms, bark, sapwood, heartwood, twigs, leaf petioles, root structures, seeds, juices—all have their specialized groups of insects adapted to feed upon them, or to utilize some of them for purposes of pupation or hibernation. The effects of such activities on plants are essentially destructive.

Over against this potentially grave destructive force, and mitigating its effects in large degree, is the ever-present fact that insects are hunted and consumed as food by practically the entire bird and mammal population, the entire spider population, and a considerable group within their own ranks. It is to this insect-consuming group of animals that the forest owes its continued existence, for it seems a fair assumption that if the activities of the birds and mammals and predaceous insects of the forest community were withdrawn or nullified in some way, the forest would soon be destroyed by the unchecked ravages of phytophagous insects.

It is true that many birds and mammals are also consumers of buds, leaves, shoots, bark, and roots of plants. While all of this has its limiting effect on plant life, it is inconsequential as compared with the effects of insect consumption of plants or of competition among plants themselves. The large consumption of seeds by birds and mammals is also inconsequential, except possibly in years of low seed production, as seeds are produced normally in enormous quantities and there is a very large surplus over and above the needs for reproduction. In fact, with the ever-present threat of serious injury to the forest dominants through the destructive activities of insects, the conversion of the surplus seed supply directly or indirectly into insect-consuming animals appears as a necessary protective

measure and a part of the mechanism whereby equilibrium in the community is maintained.

The animal population of the forest may thus be considered in relation to its effect upon plant life from two points of view—primarily as a severely limiting or potentially destructive force, as represented by the phytophagous insects, and secondarily as a protective and conserving force, as represented by the predaceous insects, spiders, birds, and mammals. In this connection it is interesting to consider how largely insects enter into the regular diet of animals usually classified as more or less strictly herbivorous or carnivorous.

The storage of nuts underground by squirrels has often been referred to as a kind of "planting" of seeds, beneficial to the forest, when such seeds are not later dug up and eaten but are left to sprout. This may be the case in areas where reforestation is in progress, but in the already established forest it is negligible as compared to the natural and normal seeding of the forest trees which is usually far in excess of the need.

An important contribution made by animals to the well-being of the plant community which should not be overlooked lies in the vast amount of stirring up of the soil that they accomplish. Shrews, mice, moles, and chipmunks are great tunnelers in soil and humus and dead wood. Many invertebrates, like the ants that work in dead wood, the insects that live under dead bark, earthworms, and many animals of minute size that are active in the humus (Jacot 1935), all contribute to this result. The plowing of the ground by red squirrels and gray squirrels as they prosecute their search for buried food is somewhat in the nature of continuous cultivation, and there is constantly added from their droppings, and from those of countless other animals, an enrichment of the soil that in the aggregate must bulk very large. Some of this stirring up of the soil is of benefit to the more deeply rooted plants in freeing them from competition with more insecurely rooted neighbors. Thus the chipmunk, nosing out the tubers of spring beauty or dwarf ginseng, makes better the conditions for growth for the seedling beech crowded in among the vigorous herbs.

Because of such interrelations plants and animals form a sociological unit, the biotic community, making a consideration of either without the other incomplete.

SUMMARY AND CONCLUSIONS

The subject of the study herein presented is a 65 acre tract of beech-maple-hemlock forest in the Cleveland, Ohio, Metropolitan Park System. Systematized work was carried on through regular weekly visits covering a period of four years. Records of temperature, precipitation, relative humidity, wind velocity, and evaporation rate were obtained.

2. Considering the vegetation of the area as a whole, it is evident that there exist here two rather distinct forest communities; a beech-maple association and a beech-hemlock-oak-chestnut mictium.

3. The beech-maple association represents the climatic climax of the region. It is mature, vigorous, stable, well established, and occupies 89 per cent of the area. It is characterized principally by the beech and the sugar maple as primary dominants, with red maple, tulip, white ash, and northern fox grape as secondary dominants. Shagbark hickory, cucumber, red oak, and white oak are listed as incidental dominants, and hop hornbeam and American hornbeam as subdominants. Other subdominant species include 12 of shrubs, 69 of herbaceous plants, 14 of ferns, 7 of climbing, twining, or trailing plants, 10 of mosses, and 6 classified as miscellaneous. Of saprophytic and parasitic plants 247 are listed. Seasonal aspects, including the responses of both plants and animals to seasonal changes, are described.

4. The beech-hemlock-oak-chestnut mictium represents a remnant of former forest communities now giving place to beech-maple. It is unstable, lacks vigor, is not well established, occupies 11 per cent of the area. It is characterized principally by the beech, the hemlock, and formerly the chestnut, as primary dominants, with red maple and red oak as secondary dominants. Shagbark hickory, cucumber, tupelo, sassafras, white oak, wild black cherry, pignut, black birch, and scarlet oak are listed as incidental dominants, and hop hornbeam and American hornbeam as subdominants. Other subdominant species include 7 of shrubs, 1 of climbing plants, 6 of herbs, and 5 of ferns.

5. One of the primary dominants of the mictium, the beech, represents the entering wedge of the climatic climax. Another, the hemlock, represents a more northern forest community left in its present position apparently as a remnant of the forest which followed the glacial ice in its northward retreat. In this community the presence of certain subdominants usually associated with hemlock is noted. The oak-chestnut remnants on the other hand represent a prominent forest community now to be found in the southern Appalachians.

6. As compared with the plants of the area the animal content presents a constant fluctuation in numbers, species, and activities. A study of the vertebrates and some invertebrates discloses the presence of 27 species of mammals, 83 of birds, 8 of reptiles, 11 of amphibians, and 20 of molluscs.

7. A study of the numbers and distribution of these animals indicates that all habitats and ecological niches in the area are well occupied when the population is at its peak, but that great changes in numbers occur both seasonally and annually. The most abundant mammals were found to be the short-tailed shrew and the white-footed mouse. Of birds 11 species were

classed as permanent residents, 8 as autumn and winter visitors, 16 as summer residents, 23 as transients, and 25 as occasional visitors. The number of nesting pairs per acre was found to average 2.3 (5.7 per hectare). Of the reptiles only one, the pilot blacksnake, was found to have important ecological relations.

8. The constituent animal species, exclusive of invertebrates, classified on the basis of abundance, activities, and influence in the community were assigned the following positions: permanent predominants 7, fluctuating predominants 3, seasonal predominants 15, permanent members 11, fluctuating members 2, seasonal members 47, incidental members 37.

9. The interrelations between plants and animals are considered, and the conclusion is reached that a consideration of either without the other is incomplete.

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[REPUBLIC OF PANAMA]

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Map of a Section of Western Panama at the Azuera Peninsula Showing Position of the Collecting Stations.

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BIRDS AND MAMALS OF THE WESTERN SLOPE OF THE AZUERO PENINSULA

INTRODUCTION

BY

J. W. ALDRICH AND B. P. BOLE, JR.

THE AZUERO PENINSULA

The Azuero Peninsula is a little-known part of Central America. It projects southwards into the Pacific Ocean from the main east-west axis of the Republic of Panama, forming the western shore of the Gulf of Panama and separating that body of water from Montijo Bay. It is 45 miles wide at its base, 70 miles wide across its sharply truncated end, and its greatest length is about 65 miles. Although there is a well marked peninsular axis or divide running at right angles to, but entirely separate from, the main cordillera of Panama, a clearer picture of the physiographic features of the peninsula may be gained by envisioning two somewhat isolated mountain masses, one in the southwestern and one occupying the southeastern parts of the peninsula. The peninsular divide runs through the length of the southwestern mass, which is much the loftier of the two. It forms the west boundary of the provinces of Herrera and Los Santos, and the eastern one of the huge land holding of the Boston-Panama Company, which lies within the large province of Veraguas. There is also a well marked divide running parallel to the main Panamanian cordillera and at right angles to the peninsular divide in the extreme southwest of the Azuero Peninsula. This ridge contains the highest peaks of the region and is everywhere from 3000 to 7000 feet in elevation. It meets the peninsular divide near Cerro Hoya, the highest peak, in the heart of a great cluster of mountains comprising the highest part of the southwestern mountain massif.

The southeastern mountain mass lies entirely to the east of the peninsular divide, within the province of Los Santos. It is connected to the other massif by a single ridge of nearly 2500 feet elevation.

PREVIOUS ZOÖLOGICAL EXPLORATIONS

So far as is known the only specimens of birds, besides those reported in this paper, to have been taken on the Azuero Peninsula are those of a collection numbering around 160 specimens obtained by Mr. Rex Benson for The American Museum of Natural History. Griscom[1] says, in reporting on this collection, that Rex Benson spent the summer of 1925 in the interior of the Cape Mala [= Azuero] Peninsula, which was found to be a mountainous region for the most part covered with heavy forest, but with only a very faint tinge of the subtropical zone. The avifauna was described as being for the most part exactly the same as that of the coastal forests farther west. From this collection Griscom described as new one bird, *Leptotila plumbeiceps malae*. Benson's collecting stations on the Azuero Peninsula were Cerro Montuosa and Cerro Largo, two small peaks a short distance north of our field of operation. It is believed that to date no zoölogical collecting has ever been done in the higher southern portion of the Azuero Peninsula range, where it is very likely that a much better representation of Subtropical Zone species would be found than were encountered by either Benson or by us, who were able to reach only the lower fringe of this zone.

Except for a group of howler monkeys collected by and for Dr. Thomas Barbour in Herrera, no mammals whatever have been recorded for the peninsula. The howlers became the basis of a hitherto unrecognized race, *Alouatta palliata trabeata* Lawrence.

In 1900-1901 J. H. Batty, who collected for The American Museum of Natural History and Walter Rothschild, secured specimens from Cebaco and Gobernador Islands just off the western coast of the Azuero Peninsula.

BOLE-ALDRICH EXPEDITION

It was the good fortune of the authors to spend the period from February 2, to April 4, 1932, collecting birds and mammals for The Cleveland Museum of Natural History on the western side of the Azuero Peninsula, in the Province of Veraguas. Collecting operations were confined to part of the land owned by the Boston-Panama

[1]Amer. Mus. Novit., No. 280, September 10, 1927, p. 1.

Company, which includes approximately 700,000 acres, bounded on the west by Montijo Bay, on the south by the Pacific Ocean, on the east by the drainage divide of the peninsula, and on the north by the River Suai. Only the drainages of the Mariato and Negro Rivers, and the uppermost parts of that of the Palo Seco River, were covered in the course of our investigations.

For the success of the expedition we are deeply indebted to the officers of the Boston-Panama Cocoanut Company, who kindly granted us permission to collect on their property and who rendered us valuable assistance in many other ways. To the resident manager, Mr. G. A. Richards, is due our deepest gratitude for his fine hospitality during our stay at the plantation headquarters, and for great assistance in obtaining the help and equipment necessary for our penetration of the rather inaccessible mountainous interior of the peninsula. The success of our collecting was furthermore enhanced through the experience and industry of Mr. P. A. Davies, our head guide and packer.

Collecting Stations

The localities given in the list of specimens under each species of bird and mammal discussed beyond, are all local native names for the places at which our various collecting stations were located. So far as is known, these are not shown on any previously published map, but the accompanying outline map will aid in their orientation. In this map the line of the sea coast and position of political boundaries were taken from the Millionth Map, Panama Sheet, Provisional Edition N. C.-17, published by the American Geographical Society, and U. S. Navy Hydrographic office charts 1018 and 1019, while the position of rivers and mountains as well as our collecting camps are according to our own field observations supplemented by the experience of our guide, Mr. P. A. Davies of Santiago, Veraguas. The rather full description of the location and nature of each collecting station seems desirable from an ecological standpoint.

Paracoté.—The native name for the small settlement at the cocoanut plantation headquarters, located about one-half mile inland from the shore of Montijo Bay and about one mile south of the Angulo River. The collecting was done in an area roughly one mile in

diameter with the settlement of Paracoté as its center. The types of habitat worked were: tidal mud flats, sandy beach, mangrove swamp, bottomland forest, cocoanut groves, and brushy roadsides, all at or very near sea level; second growth and virgin semi-deciduous forest, brushy and grassy savannahs and the vicinity of buildings at an elevation of 50 feet. The periods of collecting were February 5 to February 19, also March 20 to April 2.

Mariato River (or Rubber) Camp.—Collecting was carried on in heavy semi-deciduous forest 10 miles inland from Montijo Bay along the banks of the Mariato River, a small stream some 50 feet wide, at the point where it emerges from its steep-sided mountain valley on to the coastal plain; in second growth jungle on the site of an abandoned rubber camp; and in heavy semi-deciduous forest on the lower mountain slopes. The average elevation of the territory covered was 250 feet. The period of collecting was from February 21 to February 26.

Altos Cacao.—A small clearing some 16 miles east of Montijo Bay at 1500 feet elevation, on a steep-sided ridge between the Negro and Mariato River valleys, the site of an abandoned rubber camp. Most of the collecting was done on top of the ridge, but was occasionally carried on in the small draws that drain into the 2 rivers on both sides. The habitats covered included heavy tropical rain forest and a small cleared area of about 2 acres which had been cut over and burned 2 years previously and cultivated up to within a year of our arrival. The period of collecting was from February 28 to March 5.

Cerro Viejo Camp.—In heavy tropical rain forest at an altitude of 2000 feet on the southwest side of Cerro Viejo, 16 miles east of Montijo Bay. The period of collecting was from March 6 to March 9.

Cavulla Camp.—On top of the divide between the Azuero Peninsula's eastern and western watersheds, elevation 3000 feet; between the headwaters of the Negro and Mariato Rivers, about a mile southeast of Cerro Viejo peak and 18 miles east of Montijo Bay. The habitats in which collecting was done included open savannahs, which crowned some of the ridges, and Subtropical Zone forest between 3000 and 3200 feet in elevation. The period of collecting was from March 11 to March 14.

ECOLOGY OF THE REGION

Entirely too little time was spent in the field, aside from that necessary for the actual capture and preparation of specimens, to obtain much exact data on the nature of the biotic communities on the Azuero Peninsula. However, we believe that whenever possible it is desirable to correlate geographic distribution and geographic variation of species with ecological factors of which they are very often indicators; and for that reason, an ecological discussion of the few data available is here given.

To Dr. S. Charles Kendeigh the authors wish to express their gratitude for helpful criticisms and suggestions relative to this section of the paper.

TOPOGRAPHY AND VEGETATION

The portions of the shore-line of Montijo Bay explored by us are made up of pebbly beach, broken occasionally by mangrove bordered esteros and stream outlets with extensive mud flats exposed at low tide. Extending for about a half mile back from the bay is a low flat plain with interspersed lagoons, mangrove swamps, and bottom-land forest. This land has obviously been elevated above sea level in relatively recent geologic time, although the Montijo Bay region to the west has undergone recent submergence as evidenced by the disappearance of this coastal plain below sea level and the existence of fairly complete land mammal faunae on Coiba, Cebaco, and other islands of the region. It was on this coastal area that the cocoanut groves were planted, the original forest having been cut away for this purpose. The cocoanut plantings were kept drained by ditches in some of which tide water rose and fell. Rising rather abruptly, to about 50 feet above this low, damp, coastal strip is a rather flat or gently rolling secondary plain or piedmont, which extends eastward for about 10 miles, rising very gradually to the foot of the mountains. Here, at an elevation of approximately 250 feet above sea level, the land again begins to rise abruptly toward the crest of the divide. The plantation build-

ings and the houses of the natives who work in the cocoanut groves making up the little settlement at Paracoté are situated on the western or coastal edge of this low plateau. In the immediate vicinity of the plantation are open fields, cultivated lands, small areas of both second growth and virgin forest, and a few small llanos or grassy areas. The latter look as though they might have a natural origin, although it is entirely possible that they owe their origin to cutting followed by repeated fires during the dry season, at which time the grass becomes exceedingly dry. This is the hypothesis advanced by Cook[2] for the origin of similar areas further north in Central America and which theory is further verified by information which we obtained from residents of long standing in our particular region. As one progresses away from the plantation the forests become more unbroken and mature in character. Since the trees lose a large percentage of their leaves during the dry season, it seems likely that this semi-deciduous forest is somewhat similar to the "deciduous forests" described by Goldman[3] as characteristic of the arid division of the Lower Tropical zone of other regions on the Pacific side of Panama. However, it does not seem that the forests that we encountered were quite as completely deciduous as those that Goldman describes, since trees completely devoid of leaves were widely scattered. In the majority of cases the trees retained at least 50 per cent of their foliage. The forests of the lowlands of the western side of the Azuero Peninsula are, however, probably similar to the so-called "coastal forests" of Veraguas and Chiriqui described by Griscom.[4] The semi-deciduous nature of the forest disappears very rapidly as one rises from the low coastal plain into the mountains. At 1000 feet above sea level one can safely say that he is in the humid division of the Tropical Zone, where the trees retain most of their leaves throughout the dry season; although it is probably not as humid a habitat as certain forests of the Caribbean slope of Panama, which are said to receive an average of 180 inches of rain annually[5] and to have very little dry season. The bird population of the rain forest of the Azuero Peninsula is certainly infinitely more closely related to that of the Pacific coastal forests farther west than to the rain forest of the Caribbean slope of Panama.

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[2]U. S. Dept. Agric., Bur. Plant Ind., Bull. 145, April 10, 1909, p. 11.
[3]Smithsonian Misc. Coll., Vol. LXIX, No. 5, 1920, p. 22.
[4]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 277.
[5]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 274.

Above 1000 feet, one is in the humid tropical forest up to 3000 feet, at which elevation indications of the Subtropical Zone (or cloud forest conditions), such as heavy festooning of moss on the branches of trees, begin to put in their appearance. After ascending through a narrow strip of this cloud forest, one emerges upon open grassy savannahs which clothe the peaks and a large part of the crest of the divide in the region explored by us. The forest extends in narrow tongues along the water-courses up into these highland savannahs, the trees becoming more and more stunted and gradually disappearing altogether. The reason for the presence of the grassland at this altitude, where according to most writers there should normally be enough moisture to support heavy "cloud forest", is not known. The climatic conditions seem to be favorable for typical Subtropical Zone forest since rain and mist were of almost daily occurence during our stay there, although it was then the height of the dry season in the lowlands. Furthermore, the presence of more or less typical conditions on the mountainsides a short distance below would seem to indicate that such a growth is possible. It is very likely that the repeated setting of fires by natives, which seems to be their custom here as well as elsewhere in Central America,[6] have kept this region in grassland. The only other explanation seems to be that perpetual strong winds sweeping across the crests of the mountains are unfavorable to tree growth, a condition which is suggested by the gnarled stunted tree development at the edges of these upland savannahs, which resemble the conditions found at timberline in the mountains of temperate regions.

The crest of the mountain range described above as the southwestern massif separating Veraguas from the two other provinces on the Azuero Peninsula, Herrera, and Los Santos is surmounted on its northern end by several low peaks. The highest peaks of the mountain mass in general lie west of the drainage divide, indicating that the rivers of the Veraguas side have eaten back eastward, far beyond the original crest of the range. The only peak climbed by us is Cerro Viejo, which according to our altimeter has an elevation of 3300 feet and which lies between the headwaters of the Mariato and Negro Rivers. As we stood on the bare top of this peak we could

[6]Cook, U. S. Dept. Agric., Bur. Plant Ind., Bull. 145, April 10, 1909, p. 11.

see another, Cerro Montuosa, which seemed to us somewhat less lofty than Cerro Viejo and about 10 miles to the north. To the south rises a series of peaks, the nearest of which is Cerro Cacarañal which we estimated to have an elevation of about 4000 feet. Much farther south than this, near the southern end of the Azuero Peninsula, rises the highest peak of all, Cerro Hoya, which has an elevation of about 7000 feet. Viewed from various angles in comparison with Cerro Hoya, three other peaks to the south of Cerro Viejo appeared to be at least 5000 feet above sea level. It seems, therefore, that we were able to reach only the lower portion of this Azuero Peninsula range; and it was with much regret that we realized that time did not permit our proceeding to the higher regions that lie to the south, where it seems very likely that a rather extensive area of Subtropical Zone conditions exists. Our guide, Mr. P. A. Davies, told us that the upper slopes of Cerro Hoya are densely clothed with low trees, the branches of which are so matted and interwoven that it is often possible to walk on the tops of them. He reported that during the so-called dry season, the climate is very cold and disagreeable up there.

CLIMATIC FACTORS

The western side of the Azuero Peninsula like all of the surrounding regions of the Pacific slope of Panama has two climatic seasons, the dry season occurring normally from December to April, and the rainy season from May to November. In the coastal lowlands rainfall is exceedingly scanty during the height of the dry season in February and March, but during the wet season a surprisingly heavy precipitation is recorded. An examination of Table I shows the surprising fact that a 14-year average annual rainfall for the Mariato weather station of the Canal Zone Department of Operation and Maintenance, which corresponds to our collecting station Paracoté, was 134.07, or 12.73 inches more than a 29-year average for Gatun on the humid Caribbean slope of Panama. However, Porto Bello, another station on the Caribbean slope has a 22-year average rainfall of 156.84 inches which is considerably more than the Mariato station. It is judged from Griscom's[7] figure of 180

[7]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 270.

inches as the average annual rainfall for the whole Caribbean slope of Panama that, although high for the Pacific slope, the precipitation of the west side of the Azuero Peninsula is considerably less than that of the greater part of the Caribbean slope of Panama.

Another interesting fact to be ascertained from an examination of the table is that the average annual rainfall of the west side of the Azuero Peninsula (Mariato) is about twice that of the eastern side (Cape Mala) and also of the Pacific side of the Canal Zone (Balboa). This condition has caused the streams to erode faster on the west slope of the Azuero Peninsula with the result that they now have their origin to the east of the higher peaks as mentioned above. Although more closely approximated in the matter of average annual precipitation by the Pacific slope of extreme western Panama (Blanco), the western side of the Azuero Peninsula has a considerably higher precipitation than even that region. These facts may have some bearing on the faunal relationship between the west side of the Azuero Peninsula and other parts of the Pacific slope of Panama described beyond. The annual average of 134.07 inches of rainfall would seem to be sufficient to produce, on the western side of the Azuero Peninsula, ecological conditions more nearly approaching those of the humid Caribbean slope of Panama, if average annual rainfall were as good a criterion of ecological conditions as has been assumed by numerous writers. The important factor here seems to be not the total precipitation, but the intensity of the dry season. An examination of Table II will be illuminating when it is noticed that at the Mariato station during the months of January, February, and March the average rainfall is considerably less than the average for the same months at Gatun. This difference, coming as it does during the critical drought period, is very likely of considerable ecological importance. During our stay in the Subtropical Zone of the Azuero Peninsula from March 11 to March 14 it rained or misted nearly every day, and it is very likely that the dry season is much shorter or less complete there than on the coastal lowlands.

TABLE I

*Monthly Precipitation Data for Representative Portions of the Republic of Panama for the Year 1933**

	Pacific Slope				Caribbean Slope		
	Blanco, Chiriqui	Mariato (Paracoté)	Cape Mala	Balboa	Barro Colorado	Gatun	Porto Bello
Number of Years of Record	4	14	16	35	8	29	22
January	2.22	2.44	.88	1.19	2.49	2.61	6.90
February	.31	.55	.00	.29	.05	.20	.82
March	1.37	.00	.00	.33	1.22	.98	2.26
April	1.38	1.13	1.73	3.77	.10	.31	.92
May	13.30	17.29	10.11	6.78	7.00	8.64	8.09
June	10.11	15.75	9.13	13.14	9.42	17.67	13.19
July	9.64	15.71	6.73	5.44	9.10	12.88	9.84
August	15.85	34.89	10.67	7.54	10.23	4.96	10.66
September	15.83	24.89	7.84	5.26	9.08	11.87	10.24
October	27.77	38.80	6.10	5.18	6.39	16.54	16.31
November	27.23	27.00	9.39	10.90	32.72	41.52	28.51
December	2.64	6.38	5.37	7.95	13.93	21.67	18.95
Total, 1933	127.65	184.83	67.95	67.75	101.73	139.85	126.69
Total, 1932		133.22	62.69	69.53	113.52	150.09	163.63
Annual Aver.	118.50	134.07	66.18	68.24	105.32	121.34	156.84

*From the Annual Report of the Panama Canal Department of Operation and Maintenance for 1933.

TABLE II

*Average Precipitation during Critical Dry Season Months for Mariato and Gatun**

Station	January	February	March
Mariato 17 years	.97	.32	.29
Gatun 32 years	3.10	2.40	1.70

*From data supplied by Mr. R. Z. Kirkpatrick, Chief of Survey of the Panama Canal Department of Operation and Maintenance.

Although no satisfactory amount of data is available, the fragmentary records of Mr. G. A. Richards, resident manager of the plantation at Paracoté, would indicate that the temperature of the lowlands of the western side of the Azuero Peninsula ranges from around 71° to 82° F. during the rainy season, and from 67° to 92° F. in the dry season. The range of annual mean minimum-maximum temperatures for Balboa Heights is 73°-87.4° F., while that for

Cristobal is 76°-85.3° F., indicating a somewhat greater variation of temperature on the Azuero Peninsula than on either the Caribbean or Pacific side of the Canal Zone. Although no actual readings have been obtained for the higher altitudes, it was noticeable that as we progressed upwards in the mountains, the average day and night temperatures, and particularly the latter, were considerably lower.

A very appreciable climatic difference between the uplands and lowlands is the amount of wind. On the coast there was seldom any wind at night, in the early morning, or late afternoon, but at about 10 o'clock in the morning a breeze would always spring up and blow briskly until about 4 o'clock in the afternoon, when it would be calm again. At our highest camp, Cavulla, the wind seemed to blow incessantly day and night, and occasionally with considerable violence. On one occasion at Cavulla our tent was blown down over our heads in the night and on leaving that station a loaded pack horse was actually blown off the trail while crossing the barren top of Cerro Viejo in a gale. Mr. G. A. Richards reports that at Paracoté the dry season is considerably more windy than the wet, and that, in fact, the rainy season is conspicuous for its lack of wind.

FAUNAL RELATIONSHIPS

Basing our comparisons chiefly on Griscom's check list of the birds of Panama[8], it is noticed that the avifauna of the Azuero Peninsula, as would be expected from its location, about equidistant between the Panama Canal Zone and the Pacific slope of extreme western Panama, is related taxonomically to both. There is, however, greater relationship between the birds of the Azuero Peninsula and western Chiriqui than between those of the former locality and the Canal Zone. Disregarding the characteristically mountain species, since there are no mountains in the Canal Zone, 5 species of birds recorded from the Azuero Peninsula have been found also in western Chiriqui, but not in the Canal Zone, while 3 species have been found also in the Canal Zone and not in western Chiriqui. Of the birds that have been recorded in all these regions, 10 have subspecies common to both the Azuero Peninsula and western Chiriqui and are represented by a different geographic race in the Canal

[8]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, pp. 1-382.

Zone, while 9 others have representatives common to both the Azuero Peninsula and the Canal Zone which differ subspecifically from those found in western Chiriqui. On the other hand there are 10 avian species represented on the Azuero Peninsula by subspecies different from those found in either the Canal Zone or western Chiriqui. In 2 of these cases, *Tinamus major* and *Ortalis garrula*, the subspecies is the same on the Pacific slopes of the Canal Zone and extreme western Panama, but different on the west side of the Azuero Peninsula. One distinct species *Leptotila plumbeiceps* is present on the Azuero Peninsula and Coiba Island, but is not represented in either the Canal Zone or western Chiriqui. The species of birds concerned in these relationships are shown in Table III.

TABLE III

Relationship between Azuero Peninsula Bird Species and Those of the Panama Canal Zone and of western Chiriqui.

Specifically Related

Species recorded from Azuero Peninsula and western Chiriqui, but not the Panama Canal Zone.	*Species recorded from the Azuero Peninsula and Panama Canal Zone, but not western Chiriqui.*
Chaetura vauxi	Myiozetetes cayanensis
Campylopterus hemileucurus*	Dendroica erithachorides
Saucerottia niveoventer*	Cacicus vitellinus
Hylocharis eliciae	
Momotus momota	
Thamnophilus bridgesi	
Turdus assimilis*	
Basileuterus culicivorus*	
Tangara gyrola*	
Eucometis penicillata	

Specifically Distinct from both western Chiriqui and Panama Canal Zone Forms

Leptotila plumbeiceps†

Subspecifically Related

Species common to Azuero Peninsula and western Chiriqui, but different from those found in the Panama Canal Zone.	*Species common to the Azuero Peninsula and Panama Canal Zone, but differing from those found in western Chiriqui.*
Phaethornis superciliosa cephala	Thamnophilus doliatus nigricristatus
Notharchus hyperrhynchus dysoni	Cercomacra tyrannina rufiventris
Ceophloeus lineatus mesorhynchus	Corapipo altera altera
Pipra mentalis ignifera	Myiarchus tuberculifer brunneiceps

Mangrove and Tidal Mudflats Bordering the Estero at Paracoté. Two White Ibises (*Guara alba*), the Most Common and Characteristic Species of Bird of This Community Can be Seen in the Lower Center.

The Cocoanut Plantation at Paracoté. Many Specimens of Birds and Mammals Were Taken in Situations Such As This, and the Type Specimen of *Oryzomys azuerensis* Was Captured in the Drainage Ditch Crossed by the Board Bridge Visible in the Center of the Picture.

Bottomland Forest of Tropical Zone —
Arid Division at Paracoté.

River Bottom Forest at Mariato Rubber Camp. — Tropical Zone—Arid Division.

Tropical and Subtropical Zone Rain Forest of the Upper Negro Valley, Looking From Near the Peak of Cerro Viejo South Toward Cerro Cacarañal.

Cloud Forest of Subtropical Zone Near Our Camp at Cavulla, Altitude 3200 Feet. Cerro Cacarañal is Seen in the Distance.

Upland Llanos with Encroaching Cloud Forest at Cavulla, Subtropical Zone.

Schiffornis turdinus verae-pacis
Attila spadiceus citreopygus
Rhynchocyclus brevirostris brevirostris
Elaenia viridicata accola
Hylophilus decurtatus decurtatus
Habia rubica aurantiicapilla
Coereba flaveola columbiana
Dendroica erithachorides aequatorialis
Ramphocelus dimidiatus isthmicus
Saltator striatipictus isthmicus
Arremonops striaticeps striaticeps

Subspecifically distinct from both western Chiriqui and Canal Zone Forms

Tinamus major brunneiventris
Crypturornis soui poliocephalus
Ortalis garrula olivacea
Chaetura vauxi ochropygia
Bombornis cuvierii saturatior§
Xiphorhynchus guttatus marginatus§
Sittasomus griseicapillus veraguensis§
Manacus aurantiacus flaviventris
Pipromorpha oleaginea lutescens§
Atlapetes gutturalis azuerensis

*Mountain forms.
†Found also on Coiba Island.
§Ranges north of the Azuero Peninsula into the main cordillera of Veraguas.

Of the 22 species and subspecies of mammals of which we secured specimens, and of 2 other species frequently observed, making 24 in all, 11 are found in all three of the above-considered regions, and 6 are confined to the Azuero Peninsula. There are 5 other forms found in Chiriqui and the western side of the Azuero Peninsula but not found in the Canal Zone so far as is known. There are 2 that occur in the Canal Zone and western side of the of the Azuero Peninsula, but not in Chiriqui. Thus there is an indication that the Azuero mammal fauna, like the avifauna, has drawn more heavily on Chiriqui stock than on that of the central part of Panama; and this opinion is further strengthened when the relationships of the Azuero *Proechimys*, described in detail beyond, are investigated. However, a mere listing of the species and subspecies common to the Azuero region and either Chiriqui or the Panama Canal Zone does not fully indicate the degree of faunal interrelationship involved. Thus in Table IV there appears *Marmosa mexicana mexicana* and *Sciurus hoffmanni chiriquensis*, forms which occur on the Azuero Peninsula and in Chiriqui but not in the Panama Canal Zone. Actually there is a species of *Marmosa* in the Canal Zone, but it is not the one found on the western slope of the Azuero Peninsula. No form of *Sciurus hoffmanni* has ever been reported for the Panama Canal Zone, a case similar to that of *Marmosa*. But *Sciurus variegatoides* appears there as a dif-

ferent subspecies only, and *Nytomys sumichrasti* belongs to a genus entirely unknown there, to date. Thus the Azuero Peninsula mammals differ from those of the main Panamanian cordillera districts in varying degree; some in subspecies, some in species, and some in genus. In some cases the exact extent of the relationship in question has been indicated by arbitrary taxonomy, which then becomes the means of emphasizing the limitations of our knowledge as well as of indicating its extent. The case of *Oryzomys azuerensis* may be cited as an excellent example and the reader is referred to the general account of that form. The lists could of course be supplemented by further collecting on the Azuero Peninsula of species recorded by us but not represented in our collection by specimens.

The presence of *Nyctomys* in Table IV is felt justified, despite the fact that Goldman[9] lists this genus as one confined to the Upper Tropical Zone. There now seems to be sufficient evidence at hand to show that *Nyctomys sumichrasti* is not confined to this zone, but extends downward to sea level in various parts of Central America.

The deer is also included in the list, as ample opportunity was provided during the course of the trip properly to identify the form, although no specimens were collected.

TABLE IV

Relationship between Azuero Peninsula Mammal Species and Subspecies and those of the Pacific Slope of Chiriqui and the Panama Canal Zone

Species or subspecies common to Azuero Peninsula and western Chiriqui, but differing from related forms found in the Panama Canal Zone.	*Species or subspecies common to Azuero Peninsula and the Panama Canal Zone, but differing from related forms in western Chiriqui.*
Marmosa m. mexicana*	Liomys adspersus†
Sciurus hoffmanni chiriquensis*	Zygodontomys cherriei ventriosus
Sciurus variegatoides melania	
Nyctomys sumichrasti ssp.*	
Pecari angulatus crusniger	

Species or subspecies distinct from both those found in western Chiriqui and those in the Panama Canal Zone.

Alouatta palliata trabeata
Ateles geoffroyi azuerensis
Aotus bipunctatus†
Proechimys semispinosus goldmani
Dasyprocta punctata pallidiventris
Oryzomys azuerensis†

*Closely related forms not reported from Canal Zone. See text above for further explanation.
†Closely related forms not reported from Chiriqui.

[9]Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, p. 39.

Species or subspecies common to western Chiriqui, the western Slopes of the Azuero Peninsula and the Canal Zone.

Metachirops opossum fuscogriseus
Cebus capucinus imitator
Nasua narica panamensis
Lutra repanda
Herpailurus yaguaroundi panamensis
Felis pardalis mearnsi
Oryzomys talamancae
Sigmodon hispidus borucae
Tamandua tetradactyla chiriquensis
Odocoileus chiriquensis

The comparatively large amount of geographic variation of the birds and mammals of the western slope of the Azuero Peninsula from those of the surrounding mainland would seem to indicate that the region is to all intents and purposes insular in nature. Whether or not the highlands of the peninsula were at some time during the evolution of the present mammalian and avian forms actually separated from the mainland by water is not known. It is, however, a fact that the present tropical and subtropical rain forest communities of the region are ecologically isolated from those of the rest of the country by the arid savannahs which extend completely across the base of the peninsula to the north, thus affording almost as complete a barrier to the intermingling of rain forest elements of the Azuero Peninsula with those of the rest of Panama as would the presence of an intervening area of water of the same width. On the other hand, the semi-deciduous or gallery forests characteristic of the lowlands of the Azuero Peninsula, originally extended, according to Griscom,[10] in an unbroken belt along the Pacific coast from the Azuero Peninsula to southwestern Costa Rica. It is therefore impossible to explain on the basis of isolation the rather pronounced racial difference in certain species characteristic of this type of forest on the Azuero Peninsula from those of the same species in western Chiriqui. Such racial variation in the two regions as that found in *Tinamus major*, a rather uncommon inhabitant of the coastal forests, cannot be explained by isolation, but may very likely be due to climatic differences illustrated above by annual rainfall. The presence of the coastal gallery forest connection between the Azuero Peninsula and western Chiriqui probably does explain the greater number of forest inhabiting forms

[10]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 270.

common to those two regions than those common to the former region and the Canal Zone between which there has been no direct forest connection.

COMMUNITY RELATIONSHIPS OF BIRD AND MAMMAL POPULATIONS

Only a fragmentary sketch can be given of the composition of the biotic communities of the Azuero Peninsula since the birds and mammals were the only forms of life studied in any detail. However, as these classes of vertebrates make up a very important part of the entire biotic community, it seems desirable at least to suggest a possible community classification based on the more obvious physiographic, floral, and faunal characteristics with special emphasis on the birds and mammals occuring during the winter and early spring. Inasmuch as the ecological importance of a species depends to a large extent on its abundance, an attempt has been made to classify the birds and mammals in two groups, "common" and "uncommon". It must be admitted that the line of distinction between these groups is an arbitrary one for the most part based upon general impressions rather than actual numerical data, although in the case of birds, the frequency with which the species was seen and collected is taken into consideration. The distribution of the various mammal species under the different headings is based partly on sight records, partly on collecting data, and to a large extent on information gathered from our guides and native hunters. The distinction between the various communities discussed is likewise a rather arbitrary one. In some cases the community as here delineated might be considered too heterogeneous, such as the one classified as brushy savannahs and forest margins. Obviously this might be divided into two or more different communities, yet the exactness of the bird and mammal data available at the present time does not warrant this division. On the other hand, the distinguishing of three different forest communities might be considered inadvisable due to the very great overlapping of species. Nevertheless, some very interesting differences between faunal and floral composition of the three different forest types are noticeable and it seems desirable to give them distinct community ranking. These three forest communities probably represent three different associations or climatic climaxes, while the other communities

Coati-mundi (*Nasua narica panamensis*) Allen, Digging.
The Animal is a Young Male.

Half-grown Fawn of the Panama White-tailed Deer (*Odocoileus chiriquensis*) Allen.

Herréra Howler Monkey (*Alouatta palliata trabeata*) Lawrence, Showing the Light-Colored Flanks Characteristic of This Race. The Scrotum is Ivory White in Color.

described should be classed as associes or seral communities which are stages in the succession to the climax. It must be remembered that only the lower fringe of the Subtropical Zone was worked so that the communities discussed under this heading must be considered as ecotones between tropical and subtropical communities. The terms used to designate the major community divisions are the "life zones", now familiar to most zoögeographers, rather than "formations" which are more commonly used by ecologists. The reason for this is two fold; firstly, to tie up the more modern community concept with the older life zone system, and secondly, because our fragmentary knowledge of the vegetation of the different communities does not give us a sound basis for differentiation into formations at the present time. Further investigation in the area may disclose the presence of three distinct formations; a cloud forest, a humid tropical forest, and an arid tropical forest formation.

I. TROPICAL ZONE—Arid Division.—Sea level to approximately 1000 feet altitude.

A. *Open water of Montijo Bay.*—Surface of water and air above it.

Common Birds	Uncommon Birds
Pelecanus occidentalis californicus	Fregata magnificens magnificens
Phalacrocorax olivaceus olivaceus	

B. *Tidal mud flats, sandy beaches, mangrove swamp, lagoons and tidal ditches.*—Includes several seral communities. Vegetation chiefly mangrove trees. Open portions used for feeding areas by large numbers of birds which breed in the mangroves or which migrate from the north.

Common Birds	Uncommon Birds
Phalacrocorax olivaceus olivaceus	Butorides virescens hypernotius
Leucophoyx thula thula	Casmerodius albus egretta
Hydranassa tricolor ruficollis	Nyctanassa violacea violacea
Guara alba	Mycteria americana (migrant)
Charadrius semipalmatus (migrant)	Ajaia ajaja
Actitis macularia	Buteogallus anthracinus subtilis
Totanus melanoleucus	Falco albigularis albigularis
Ereunetes pusillus	Aramides cajanea cajanea
Chaetura vauxi ochropygia	Squatarola squatarola (migrant)
Chloroceryle americana isthmica	Numenius hudsonicus
Iridoprocne albilinea	Catoptrophorus semipalmatus subsp. (migrant)
	Tringa solitaria subsp. (migrant)

Mammals

Procyon sp.

Uncommon

Birds

Limnodromus griseus subsp. (migrant)
Chloroceryle aenea aenea
Protonotaria citrea (migrant)
Dendroica erithachorides aequatorialis
Icterus galbula

Mammals

Oryzomys azuerensis

C. Cultivated cocoanut groves and the vicinity of houses.—A rather heterogeneous artificial community yet not readily divisable. Vegetation: large groves of cocoanut trees beneath which grow grass and brush; shade and fruit trees and cultivated shrubs.

Common

Birds

Coragyps atratus foetens
Cathartes aura subsp.
Buteo magnirostris ruficaudus
Columbigallina rufipennis rufipennis
Leptotila verreauxi verreauxi
Amazona autumnalis salvini
Aratinga ocularis
Crotophaga sulcirostris sulcirostris
Nyctidromus albicollis intercedens
Lepidopyga caeruleogularis caeruleogularis
Amazilia tzacatl tzacatl
Hylocharis eliciae
Chlorostilbon assimilis
Centurus rubricapillus wagleri
Thamnophilus doliatus nigricristatus
Tyrannus melancholicus chloronotus
Myiodynastes maculatus nobilis
Elaenia chiriquensis chiriquensis
Troglodytes musculus inquietus
Turdus grayi casius
Coereba flaveola columbiana
Thraupis episcopus diaconus
Ramphocelus dimidiatus isthmicus
Sporophila aurita aurita
Volatinia jacarini atronitens
Saltator maximus intermedius
Arremonops striaticeps striaticeps

Mammals

Zygodontomys cherriei ventriosus
Sigmodon hispidus borucae
Sylvilagus gabbi ssp.
Rattus rattus rattus
Herpailurus yaguaroundi panamensis

Uncommon

Birds

Cathartes aura teter (migrant)
Buteogallus anthracinus subtilis
Milvago chimachima cordatus
Actitis macularia (migrant)
Columbigallina minuta elaeodes
Brotogeris jugularis jugularis
Chaetura vauxi ochropygia
Florisuga mellivora mellivora
Bombornis cuvierii saturatior
Elaenia flavogastra pallididorsalis
Thraupis palmarum atripennis
Oryzoborus funereus

Mammals

Liomys adspersus

D. *Brushy savannahs and forest margins.*—Another heterogeneous community, yet not divisible even as to arid and humid divisions; probably including several distinct seral communities in the succession from open grassland to climax forest. Small grassy savannahs, shrubs, and small trees, particularly cecropias and "sandpaper" trees. Probably a fire subclimax condition.

Common Birds	Uncommon Birds
Crypturornis soui poliocephalus	Coragyps atratus foetens
Buteo magnirostris ruficaudus	Cathartes aura subsp.
Ortalis garrula olivacea	Odontriorchis palliatus
Crotophaga sulcirostris sulcirostris	Accipiter bicolor bicolor
Aratinga ocularis	Buteo platypterus platypterus
Brotogeris jugularis jugularis	Herpetotheres cachinnans cachinnans
Amazona autumnalis salvini	Columba speciosa
Nyctidromus albicollis intercedens	Columba rufina pallidicrissa
Lepidopyga caeruleogularis caeruleogularis	Pionus menstruus
Amazilia tzacatl tzacatl	Piaya cayana incincta
Hylocharis eliciae	Chaetura vauxi ochropygia
Chlorostilbon assimilis	Trogon massena massena
Centurus rubricapillus wagleri	Xiphorhynchus guttatus marginatus
Thamnophilus doliatus nigricristatus	Tityra semifasciata costaricensis
Tyrannus melancholicus chloronotus	Megarhynchus pitangua mexicanus
Myiodynastes maculatus nobilis	Myiozetetes cayanensis harterti
Myiarchus ferox panamensis	Elaenis flavogastra pallididorsalis
Elaenia chiriquensis chiriquensis	Thryothorus modestus elutus
Turdus grayi casius	Dumetella carolinensis
Polioptila plumbea bilineata	Basileuterus delattrii mesochrysus
Thraupis episcopus diaconus	Oryzoborus funereus
Ramphocelus dimidiatus isthmicus	Saltator striatipictus isthmicus
Sporophila aurita aurita	
Volatinia jacarini atronitens	Mammals
Saltator maximus intermedius	Bassariscus sumichrasti ssp.
Arremonops striaticeps striaticeps	Potos flavus ssp.
Mammals	
Herpailurus yaguaroundi panamensis	
Zygodontomys cherriei ventriosus	
Sigmodon hispidus borucae	
Sciurus hoffmanni chiriquensis	
Dasyprocta punctata pallidiventris	

E. *Semi-deciduous coastal forest.*—Probably the climatic climax. Characterized by large trees which lose a large percentage of their leaves during the dry season except on river borders and bottomland where conditions are similar to those in the rain forest community, and which probably accounts for the presence in the semi-deciduous forest region of many species which would not otherwise be there. The shrub stratum is occupied almost entirely by vines which hang from the branches of the trees. The forest floor is destitute of ground cover either herbaceous or otherwise at least during the dry season.

Common Birds	Uncommon Birds
Momotus momota lessonii	Tinamus major brunneiventris
Malacoptila panamensis panamensis	Crypturornis soui poliocephalus
Rhamphastos sulphuratus brevi-carinatus	Sarcoramphus papa
	Cathartes aura subsp.

Common Birds

Thamnophilus bridgesi
Myrmeciza exul occidentalis
Xenops minutus ridgwayi
Xiphorhynchus guttatus marginatus
Chiroxiphia lanceolata
Manacus aurantiacus flaviventris
Schiffornis turdinus verae-pacis
Myiarchus crinitus boreus (migrant)
Myiarchus tuberculifer brunneiceps
Myiobius atricaudus atricaudus
Rhynchocyclus brevirostris brevirostris
Cyanocorax affinis zeledoni
Hylophilus decurtatus decurtatus
Vermivora peregrina (migrant)
Amblycercus holosericeus centralis

Mammals

Nasua narica panamensis
Lutra repanda
Sciurus variegatoides melania
Oryzomys talamancae
Proechimys semispinosus goldmani
Dasyprocta punctata pallidiventris
Alouatta palliata trabeata
Cebus capucinus imitator

Uncommon Birds

Daptrius americanus guatemalensis
Penelope purpurascens aequatorialis
Actitis macularia (migrant along streams)
Claravis pretiosa pretiosa
Leptotila plumbeiceps malae
Nyctidromus albicollis intercedens
Phoethornis superciliosa cephala
Saucerottia niveoventer
Hylocharis eliciae
Trogon massena massena
Megaceryle torquata torquata (along streams)
Chloroceryle americana isthmica (along streams)
Phloeoceastes melanoleucus malherbii
Sittasomus griseicapillus veraguensis
Pachyrhamphus polychropterus cinereiventris
Terenotriccus erythrurus fulvigularis
Atalotriccus pilaris wilcoxi
Elaenia viridicata accola
Tyranniscus vilissimus parvus
Thryothorus rufalbus castanonotus
Vireosylva flavoviridis flavoviridis (migrant)
Mniotilta varia
Dendroica pensylvanica (migrant)
Oporornis formosus (migrant)
Setophaga ruticilla (migrant)
Tangara larvata franciscae
Eucometis penicillata stictothorax

Mammals

Marmosa mexicana mexicana
Tayra barbara ssp.
Nyctomys sumichrasti ssp.
Aotus bipunctatus

II. TROPICAL ZONE—Humid Division.—Altitude 1000-3000 feet, and extending down along the river bottoms onto the coastal plain.

A. *Rain forest community.*—A homogeneous climax community characterized by broad-leafed evergreen trees of great height and luxuriance. Espave, almiendro, and castilla rubber trees conspicuous. The shrub stratum is occupied by true shrubs, tree fern and small palms as well as vines. Herbaceous ground cover absent except along streams, at least during the dry season.

Common Birds

Tinamus major brunneiventris
Cathartes aura subsp.
Penelope purpurascens aequatorialis
Malacoptila panamensis panamensis

Uncommon Birds

Sarchoramphus papa
Leucopternis albicollis costaricensis
Crax rubra rubra
Leptotila plumbeiceps malae

Common	Uncommon
Birds	Birds
Rhamphastos sulphurastus brevicarinatus	Antrostomus carolinensis (migrant)
Myrmeciza exul occidentalis	Nyctidromus albicollis intercedens
Xiphorhynchus guttatus marginatus	Phaethornis superciliosa cephala
Pipra mentalis ignifera	Saucerottia niveoventer
Chiroxiphia lanceolata	Amazilia tzacatl tzacatl
Corapipo altera altera	Hylocharis eliciae
Manacus aurantiacus flaviventris	Klais guimeti
Schiffornis turdinus verae-pacis	Momotus momota lessonii
Myiarchus crinitus boreus (migrant)	Ceophloeus lineatus mesorhynchus
Myiarchus tuberculifer brunneiceps	Sittasomus griseicapillus veraguensis
Pipromorpha oleaginea lutescens	Thamnophilus bridgesi
Thryothorus rutilus hyperythrus	Myrmotherula fulviventris
Turdus assimilis cnephosus	Cercomacra tyrannina rufiventris
Cyanerpes cyaneus carneipes	Attila spadiceus citreopygus
Chlorophanes spiza arguta	Pachyrhamphus polychropterus cinereiventris
	Tolmomyias sulphurescens flavo-olivaceus
Mammals	Elaenia viridicata accola
Cebus capucinus imitator	Ramphocaenus rufiventris sanctae-marthae
Alouatta palliata trabeata	Vireosylva flavoviridis flavoviridis (migrant)
Nasua narica panamensis	Vireosylva flavoviridis insulana
Lutra repanda	Vireosylva philadelphica (migrant)
Nyctomys sumichrasti ssp.	Cyanerpes lucidus isthmicus
Proechimys semispinosus goldmani	Oporornis formosus
	Basileuterus culicivorus godmani
	Phaeothlypis fulvicauda veraguensis (along streams)
	Amblycercus holosericeus centralis
	Tanagra laniirostris crassirostris
	Habia rubica aurantiicapilla
	Arremon aurantiirostris aurantiirostris
	Mammals
	Ateles azuerensis
	Oryzomys talamancae

III. SUBTROPICAL ZONE—Altitude 3000 feet and above.—Only the lower fringe explored by us.

A. *Savannah and forest margin.*—Characterized by grassy savannah and small trees. No birds present in the open grassy areas. Probably a fire subclimax condition.

Common	Uncommon
Birds	Birds
Chaetura vauxi ochropygia	Cathartes aura subsp.
Arremonops striaticeps striaticeps	Elanoïdes forficatus yetapa
Atlapetes gutturalis azuerensis	Bureo platypterus platypterus (migrant)
	Aramides cajanea cajanea (along streams)
Mammals	Amazilia tzacatl tzacatl
Sciurus hoffmannii chiriquensis	Myiarchus ferox panamensis
Sigmodon hispidus ssp.	Elaenia flavogastra pallididorsalis
	Elaenia chiriquensis chiriquensis

B. *Cloud forest.*—The climatic climax, characterized by a luxuriant growth of trees heavily festooned with moss.

Common	Uncommon
Birds	Birds
Rhamphastos sulphurastus brevicarinatus	Elanoïdes forficatus yetapa
Corapipo altera altera	Leucopternis albicollis costaricensis
Pipromorpha oleaginea lutescens	Oreopeleia montana
Turdus assimilis cnephosus	Campylopterus hemileucurus
	Schiffornis turdinus verae-pacis
	Sittasomus griseicapillus veraguensis
Mammals	Myiarchus tuberculifer brunneiceps
Nyctomys sumichrasti ssp.	Elaenia viridicata accola
	Basileuterus culicivorus godmani
	Phaeothlypis fulvicauda veraguensis (along streams)
	Tangara gyrola bangsi
	Habia rubica aurantiicapilla

Certain of the species of mammals are very widely ranging and occur in all the terrestrial communities. The big game species—the three pigs, the deer and the large cats including the ocelot, fall into this category, as do *Didelphis*, *Metachirops*, and *Tamanduas*. Presumably the gray fox and armadillo would also fall into this group.

ANNOTATED LIST OF BIRDS OF THE WESTERN SLOPE OF THE AZUERO PENINSULA

BY J. W. ALDRICH

The species of birds discussed here were all observed by the writer on the western slope of the Azuero Peninsula and adjoining water of Montijo Bay. Of the 164 species recorded, 147 were collected and are represented in the collection of 509 specimens brought back and preserved in The Cleveland Museum of Natural Hustory.

The systematic status of all the species represented by collected specimens has, with but few exceptions, been carefully worked out by comparison with adequate series of specimens. Due to the inadequacy of Central American material in The Cleveland Museum of Natural History it was necessary to borrow a considerable number of specimens from other museums and private collections. For the loan of material for comparison the writer is indebted to the authorities of The Academy of Natural Sciences of Philadelphia, the American Museum of Natural History, Carnegie Museum, Field Museum of Natural History, Museum of Comparative Zoölogy, Museum of Zoölogy at the University of Michigan, United States Biological Survey, and United States National Museum; also to Mr. Herbert W. Brandt, and Mr. H. B. Conover. For useful advice on the status of certain forms and in the preparation of the manuscript, the writer is grateful to Dr. Herbert Friedmann, Mr. Ludlow Griscom, Mr. N. B. Kinnear, Dr. Harry C. Oberholser, Mr. James L. Peters, Mr. A. J. Van Rossem, and Dr. Josselyn Van Tyne. The kindness of Dr. Harry C. Oberholser and Mr. Ludlow Griscom in reading over the entire manuscript and making helpful suggestions is especially appreciated.

In the systematic study of the specimens all measurements were taken according to the methods recommended by Baldwin, Oberholser, and Worley[11] while descriptions of plumage coloration are based on Ridgway's key.[12] Common names are derived from Ridgway's "Birds of North and Middle America",[13] insofar as the forms involved were covered by that work. Where other forms were present in the collection, Brabourne and Chubb's "Birds of South Amer-

[11]Sci. Pub. Clev. Mus. Nat. Hist., Vol. II, 1931.
[12]Color Standards and Color Nomenclature, 1912, pp. I-IV, 1-44, 53 plates.
[13]Bull. U. S. Nat. Mus., No. 50, Parts 1-8, 1901-1919.

ica",[14] Swann's "Monograph of the Birds of Prey",[15] and Cory and Hellmayr's "Catalogue of the Birds of the Americas"[16] were resorted to.

Tinamus major brunneiventris, subsp. nov. BROWN-BREASTED TINAMOU.

Subspecific Characters.—Nearest *Tinamus major castaneiceps*, but under parts distinctly more brownish (more predominantly olive brown rather than grayish olive), and less distinctly barred; sides of head and neck much darker (outer portions of feathers auburn, rather than ochraceous tawny); chestnut of pileum averaging darker, and extending farther down on the sides of the head. It differs from *Tinamus major saturatus* in the same way as from *T. m. castaneiceps*, particularly in being more brownish below. Also it lacks the elongated crest of the former race.

Measurements.—*Adult male* (4 specimens from southern Veraguas): wing, 222-240 (average, 232.3) mm.; tail, 84-89 (86); exposed culmen, 30-32 (31.3); tarsus, 68-72 (69). *Adult female* (2 specimens from southern Veraguas): wing, 240-244 (average, 242) mm.; tail, 89-92 (90.5); exposed culmen, 30-32 (31); tarsus, 69-72 (70.5).

Type.—Adult male, No. 22002, Cleveland Museum of Natural History; Paracoté, elevation sea level, 1 mile south of the mouth of the Angulo River, Veraguas, Panama; March 21, 1932; P. A. Davies and J. W. Aldrich, original number, 1995.

Geographic Distribution.—The heavily forested region of southern Veraguas, Panama.

Remarks.—The brownish breast of *Tinamus major brunneiventris* is a very pronounced distinguishing character. The darker pigmentation of the sides of the head and neck are also very noticeable in typical examples of this form. Although there is a decided individual variation in the color of the under parts even among our specimens, any bird in the series from the Azuero Peninsula might be separated at a glance by this character from any specimen of any other race of *Tinamus major* that the writer has seen. In respect to breast color, the closest approach to the southern Veraguas birds

[14]Birds of South America, Vol. I, December 20, 1912.
[15]Monograph of the Birds of Prey, Parts 1-13, November 15, 1924 to December, 1935.
[16]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Parts 2-9, March, 1918 to October 6, 1936.

is found in a specimen among the several seen from Divala. A single specimen in the American Museum of Natural History from Wilcox Camp in southern Veraguas on the west side of Montijo Bay, is typical of *T. m. brunneiventris* in the amount of brown on the under parts, and should be referred to that race, although tending toward *T. m. castaneiceps* in the amount of barring on the breast and in the color of the sides of head and neck.

Tinamus major castaneiceps intergrades with *Tinamus major saturatus* in eastern Panama, specimens from Jesusito being intermediate. The range of *T. m. castaneiceps* therefore must extend along the forested portions of the Pacific slope of the central cordillera from Costa Rica to eastern Panama, including the Pacific coastal forests of extreme western Panama. The range of the new race, *Tinamus major brunneiventris*, is, to the north, separated from that of *T. m. castaneiceps* in Veraguas by the savannahs of Panama, but intergrades with it in the coastal forests of Veraguas and Chiriqui west of the Azuero Peninsula.

The material examined in the study of this species consisted of 14 specimens of *Tinamus major castaneiceps* from southwestern Costa Rica and western Chiriqui (Divala), and 3 from eastern Panama (Cerro Azul and Jesusito); 12 of *Tinamus major saturatus*, including the type, from eastern Panama (Port Obaldia, Cana, and Mt. Pirri); and 6 *Tinamus major brunneiventris*, from southern Veraguas, Panama.

Brown-breasted tinamous were fairly common in the deep Tropical Zone forests at all altitudes visited, but more so in the more humid portions above 1000 feet. It was not seen, however, in the cloud forest at 3000 feet. The birds were occasionally flushed, but were more often heard. They were most frequently encountered along stream beds, particularly during the hotter part of the day, at which time they apparently stay near water. As they flushed, the roar of their wings was very reminiscent of the ruffed grouse of our more familiar North American woodlands. Their musical, whinnying whistle was most frequently heard in the latter part of the afternoon, particularly about sunset, but occasionally late at night.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	Date
22001	♀	Altos Cacao	1500 feet	March 5, 1932
22002	♂	Paracoté	Sea level	March 21, 1932
22003	♂	Paracoté	Sea level	March 21, 1932
22004	♀	Paracoté	Sea level	March 28, 1932

Crypturornis soui poliocephalus, subsp. nov. GRAY-HEADED TINAMOU.

Subspecific Characters.—Nearest *Crypturornis soui panamensis*, but the male with head much paler and more grayish (less brownish); the female with head slightly more grayish (less brownish), and under parts more purely cinnamon rufuous (less washed with brownish) particularly on chest and flanks. From *Crypturornis soui modestus* it is distinguishable by a very marked sex color difference (there being, as pointed out by Griscom,[17] practically no difference in the color of the male and female of *C. s. modestus*); male with a very much paler gray head (mouse gray instead of dark mouse gray on the sides of head, neck, and lores); pileum dark mouse gray, washed with brown, instead of fuscous black; body much more tawny (less grayish) below, and more reddish brown (bister rather than clove brown) above. Both sexes are separable from *Crypturornis soui harterti* by their paler (less dusky) coloration throughout.

Measurements.—*Adult male* (4 specimens from the Azuero Peninsula): wing, 123.5-132 (average, 127.3) mm.; tail, 37.5-43 (40.1); exposed culmen, 19-20.5 (19.5); tarsus, 38.5-41 (39.8). *Adult female* (2 specimens from the Azuero Peninsula): wing, 136-139 (average, 137.3) mm.; tail, 42.5-43.5 (43); exposed culmen, 19.5-20.5 (20); tarsus, 42.5-43.5 (43).

Type.—Adult male, No. 22006, Cleveland Museum of Natural History; Paracoté, elevation sea level, east shore of Montijo Bay, 1 mile south of the mouth of the Angulo River, Veraguas, Panama, March 28, 1932; P. A. Davies and J. W. Aldrich, original number 2065.

Geographic Distribution.—Probably all of the Pacific slope of Veraguas, and possibly eastern Chiriqui, Panama.

[17]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 310.

Remarks.—A comparison of our series with 15 specimens of *Crypturornis soui panamensis*, including the type and 4 topotypes, showed that the subspecific characters of *Crypturornis soui poliocephalus* are rather constant, particularly the pale gray head of the male. A single male in the U. S. National Museum collection, from Nata, in the Province of Coclé, a locality almost exactly half way between the type locality of *C. s. poliocephalus* and Loma del Leon, whence came the type of *C. s. panamensis*, is, in the color of its head, almost exactly intermediate between the two races, but is probably better referred to the latter. No specimens have been seen that would determine the northern and western limits of the range of *Crytpurornis soui poliocephalus*. However, since Griscom[18] has found that the bird of the Caribbean coast of Panama is *Crypturornis soui harterti*, the central cordillera is probably the northern limit of the range of our new form. To the west, intergradation with *Crypturornis soui modestus* probably occurs somewhere between the Azuero Peninsula and western Chiriqui.

Since, after considerable study, Dr. H. C. Oberholser is convinced that tinamous of the *soui* group as well as other species are generically distinct from the two species that belong to the genus *Crypturellus*, I prefer to use his proposed name of *Crypturornis*[19] for the species under consideration, instead of *Crypturellus*, the name recently applied to this as well as to all the other species included in the genus formerly called *Crypturus*.

The low bushy tangles and young forests about the plantation at and near sea level were the only localities which seemed to supply the proper habitat for this little gray-headed tinamou, but in such haunts it was fairly common.

A male and a female, collected on April 2, were found together at the edge of a small woodland and were apparently a mated pair. The female, on dissection, was found to contain an egg almost ready for laying. Judging from this evidence and from the fact that there was a very noticeable increase in the frequency of the songs during the first part of April, this month appears to fall within the breeding season of the gray-headed tinamou.

[18]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 309.
[19]Proc. Biol. Soc. Washington, Vol. 35, March 20, 1922, pp. 73-75.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22005	♂	Paracoté	Sea level	March 24, 1932
22006	♂	Paracoté	Sea level	March 28, 1932
22007*	♀	Paracoté	Sea level	March 30, 1932
22008	♂	Paracoté	50 feet	April 2, 1932
22009	♂	Paracoté	50 feet	April 2, 1932
22010	♀	Paracoté	50 feet	April 2, 1932

*Contained egg almost ready to be laid.

Pelecanus occidentalis californicus Ridgway. CALIFORNIA BROWN PELICAN.

Brown pelicans were seen rather frequently flying over Montijo Bay, and occasionally resting in the outer edge of the mangroves fringing the estero at Paracoté.

Since the name of the subspecies of brown pelican which occurs on the Pacific coast of Panama is apparently open to difference of opinion, and since no specimens were taken by us, it is not possible to allocate definitely the birds that we saw. However, the probabilities strongly favor *Pelecanus occidentalis californicus*. Griscom[20] uses that name for the brown pelican that occurs along the entire Pacific coast of Panama, "breeding abundantly". Murphy,[21] on the other hand, refers the birds on the Pacific coast of Panama to *Pelecanus occidentalis carolinensis*, but admits that adequate material is not available at the present time to make any very definite statement as to the status of the birds of that region.

Phalacrocorax olivaceus olivaceus (Humboldt). BRAZILIAN CORMORANT.

The single specimen is an immature bird apparently in transition from the first year to the second year plumage, since the sides of the head, throat, neck, and chest are white, flecked with brown feathers. The sides and belly are almost black but with a whitish wash in the center of the latter, from which there is anteriorly a gradual transition to the white of the chest. The tail is in process of molt. The measurements of this specimen are interesting, inasmuch as they are rather large for this form: wing, 280 mm.; tail, 159; exposed culmen, 55; tarsus, 53.

[20]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 292.
[21]Oceanic Birds of South America, Vol. II, February 21, 1936, pp. 807-808.

Brazilian cormorants were common along the beaches and salt water lagoons bordering Montijo Bay, as well as on the open water of the bay itself.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22011	♀	Paracoté	Sea level	February 14, 1932

Fregata magnificens magnificens Mathews. MAN-O'-WAR BIRD.

Man-o'-war birds were seen occasionally wheeling on motionless pinions over Montijo Bay.

Peters[22] refers the birds of this species that occur along the Pacific coast of Panama and that breed on the Pearl Islands to *Fregata magnificens magnificens*. Murphy,[23] however, is unwilling to recognize the bird of the Pacific coast of Panama as distinct from the Caribbean coast form, *Fregata magnificens rothschildi*, since considerable numbers of these superb flyers are known to pass regularly back and forth across the Isthmus of Panama. In the writer's opinion the freedom of passage of the breeding form of the Caribbean coast back and forth across the Isthmus of Panama would not interfere with the occurence of a different subspecies as the breeding form of the Pacific coast of Panama any more than the mingling, during the non-breeding season, interferes with the well established status of geographic races of such migrant species as the horned lark (*Otocoris alpestris*) and the Savannah Sparrow (*Passerculus sandwichensis*). Inasmuch as we collected no specimens, it is impossible to say definitely whether the occasional man-o'-war birds that we saw over Montijo Bay belonged to the breeding colonies of the Pearl Islands or to those of the Caribbean Sea. However, the probabilities strongly favor the former case.

Butorides virescens hypernotius Oberholser. PANAMA GREEN HERON.

The single specimen obtained measures as follows: wing, 173 mm.; tail, 61; exposed culmen, 60; tarsus, 50. These measurements seem to be closer to the averages of *Butorides virescens hypernotius*, as given

[22]Check List of Birds of the World, Vol. 1, October 6, 1931, p. 95.
[23]Oceanic Birds of South America, Vol. II, February 21, 1936, p. 920.

by Oberholser,[24] than to those of *Butorides virescens virescens*. Furthermore, the date (April 2) is late for an individual of the latter race to be so far south of its breeding range. Should I follow the example of Peters[25] and other recent writers and consider our specimen referable to *Butorides virescens maculatus*, which name seems to be currently used to embrace most of the green herons of eastern and southern Central America, I would be obscuring the facts. The wing measurement of our bird is closer to the average of *B. v. virescens* than to the average given by Peters[26] for *B. v. maculatus*. But to refer our specimen to *B. v. virescens* would involve giving this race a discontinuous range, since the locality of our specimen and that of topotypical *B. v. hypernotius* of the Canal Zone are cut off from *B. v. virescens* by the smaller forms, *Butorides virescens mesatus* of western Nicaragua, and so-called *B. v. maculatus* of the eastern coast of Central America as far south as Almiranti.[27] It seems, therefore, that, although *B. v. hypernotius* is admittedly close to *B. v. virescens*, differing only in averaging smaller, since its range is isolated by intervening still smaller forms of the green heron, it ought to be considered a distinct subspecies. There are many parallel cases of commonly recognized subspecies, which though resembling one another very closely, are separated by a more distinct form. Examples which come to mind occur in the species *Otocoris alpestris* and *Atlapetes gutturalis*. In the case of the latter, this phenomenon of parallelism will be discussed later in the present paper.

The back of our specimen is rather more purplish than any specimen of any race examined, except some examples of *Butorides virescens margaritophilus*, of which I have seen 20 specimens from the Pearl Islands; our Panama specimen was, however, considerably larger than any of these. The color of the back may, nevertheless, indicate some intergradation towards the Pearl Islands bird even though the size points in the opposite direction, being slightly greater than the average of *B. v. hypernotius*.

Green herons were seen occasionally in the mangrove borders of the estero at Paracote, but were not nearly as abundant as most of the other species of herons and ibises with which they associated.

[24]Proc. U. S. Nat. Mus., Vol. XLII, August 29, 1912, p. 550.
[25]Bull. Mus. Comp. Zoöl., Vol. LXXI, No. 5, February, 1931, pp. 305-307.
[26]Check List of Birds of the World, Vol. I, October 6, 1931, pp. 103-104.
[27]Peters, Bull. Mus. Comp. Zoöl., Vol. LXXI, No. 5, February, 1931, pp. 305-307.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22015	♀	Paracoté	Sea level	April 2, 1932

Casmerodius albus egretta (Gmelin). AMERICAN EGRET.

Although not as common as the smaller species of herons such as the snowy egret, Louisiana, and yellow-crowned night herons, the American egret was seen on at least two occasions in the mangroves bordering the estero at Paracoté. On one of these occasions the handsome white bird was walking about among the mangrove roots in close companionship with a roseate spoonbill, the contrast of pink and white making a combination very pleasing to the eye. No specimens of the American egret were collected.

Leucophoyx thula thula (Molina). SNOWY EGRET.

The single specimen taken is apparently an immature male in the first nuptial plumage, described by Bent,[28] as there is only a trace of the plumaceous condition of the back feathering.

Snowy egrets were rather common on the mud flats and in the outer edge of the mangroves bordering the estero at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22014	♂	Paracote	Sea Level	March 29, 1932

Hydranassa tricolor ruficollis (Gosse). LOUISIANA HERON.

The only specimen obtained is an adult female in full breeding plumage.

Louisiana herons were fairly common, mixed in groups of other species of herons feeding at the edges of the mud flats at low tide and in the mangroves fringing the bay.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22013	♀	Paracote	Sea Level	March 29, 1932

[28]Bull. U. S. Nat. Mus., No. 135, March 11, 1927, p. 151.

Nyctanassa violacea violacea (Linnaeus). YELLOW-CROWNED NIGHT HERON.

The only specimen taken was apparently a two year old female in what Bent[29] describes as the second nuptial plumage. The measurements seem to indicate an intergradation toward *Nyctanassa violacea bancrofti* in this region. However, this specimen is nearer the average of *N. v. violacea*, and is therefore referred to that race. It measures: wing, 301 mm.; tail, 113; tarsus, 100; culmen, 70; height of bill at base, 24; width of bill at base, 20.

Yellow-crowned night herons were seen occasionally in the mixed groups of herons and ibises that frequented the mud flats at low tide.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22012	♀	Paracoté	Sea Level	March 30, 1932

Mycteria americana Linnaeus. WOOD IBIS.

The wood ibis was seen only during the period from February 5 to 19, at one large but rapidly drying lagoon where the single specimen was collected, and in small flocks flying northward over the plantation. It was evident that these birds were migrating at this time, and they had all left the region before we returned to the plantation from our mountain trip on March 19.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22016	♂	Paracoté	Sea Level	February 15, 1932

Guara alba (Linnaeus). WHITE IBIS.

The white ibis seemed to be the most abundant species of the ibis-heron aggregation to be found on the mud flats at low tide. Both the adult and immature plumages were represented in these groups. This species was found also in the mangrove swamps bordering the bay, most abundantly at the outer edge.

[29]Bull. U. S. Nat. Mus., No. 135, March 11, 1927, p. 216.

Specimens Collected

C. M. N. H. Numbe	*Sex*	*Locality*	*Elevation*	*Date*
22017	♂	Paracoté	Sea Level	March 29, 1932
22018	♂	Paracoté	Sea Level	March 30, 1932
22019	♂im.	Paracoté	Sea Level	March 30, 1932
22020	♀	Paracoté	Sea Level	March 30, 1932
22021	♀im.	Paracoté	Sea Level	March 30, 1932

Ajaia ajaja (Linnaeus). ROSEATE SPOONBILL.

The single specimen taken was in first winter plumage, with feathered head. Another roseate spoonbill was observed feeding in the shallow water among the mangroves. The method of feeding was to move the bill from side to side at the surface of the water, rapidly opening and closing the mandibles in much the same manner that a duck feeds on floating matter. The species was not common.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22022	—im.	Paracoté	Sea Level	March 30, 1932

Sarcoramphus papa (Linnaeus). KING VULTURE.

Since I have been unable to find a complete description of the remarkable head coloring of the king vulture in any of the literature, I give the following description of the colors of the bill and bare skin of the head of the below recorded specimen, No. 22023, taken less than one hour after the death of the bird.

Nape (greatly thickened and wrinkled skin) yellow; posterior auricular region flesh color washed with purplish red; sides of throat reddish orange; middle of throat yellowish orange; area of thickened and greatly wrinkled skin on side of head running in a reverse S-shaped curve from nape to angle of jaw, reddish orange on dorsal fourth, bluish gray on adjoining fourth (on same plane with eye), and gray on remaining (ventral) half; crown reddish orange; ring around eye red; remainder of sides of head purplish red; cere and caruncle orange; anterior two thirds of bill dull red; posterior third black; iris white. This description was compared with that of specimen 22024, taken about a week later, with which it coincided perfectly.

This species was first encountered on February 25 at the Mariato River camp, where a single individual came to feed with the turkey vultures on skinned carcasses of monkeys placed on the dry river bed. This individual appeared as a circling black and white speck in the sky, which suddenly began to grow rapidly larger, accompanied by a steadily increasing hissing sound as the vulture plunged downward with partially closed wings. As the great bird approached the earth, the hissing of the air between its quills assumed the proportions of the sound caused by a diving airplane which has had its motor shut off. The vulture terminated its mighty plunge from the clouds in a graceful upward sweeping curve and landed in the top of a giant fig tree which towered above our camp on the river bank. Later, when this bird was collected, a porcupine quill was found imbedded in the bare skin of its neck in the region of the crop, bearing mute testimony to the nature of some former meal.

At Altos Cacao on March 4, as many as seven of these vultures were seen in the air at once. Here, also, they came to feed on skinned carcasses with the turkey vultures. The arrival of these big scavengers was always announced by the characteristically loud and prolonged swish of the air through their plumage, caused by their plunging descent. When one or more king vultures were present at the carrion, the turkey vultures stood respectfully aside until the heavier bodied fellows had finished.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22023	—	Mariato River Camp	250 Feet	February 25, 1932
22024	♂	Altos Cacao	1500 Feet	March 4, 1932

Coragyps atratus foetens (Lichtenstein). SOUTH AMERICAN BLACK VULTURE.

In order to determine the status of the Panama black vulture, the writer has examined, in all, eight specimens from that country as follows: the specimen listed below from the Azuero Peninsula; one specimen from Saboga Island, Bay of Panama, in the Museum of Comparative Zoölogy; and six specimens from Port Obaldia on the Caribbean coast of extreme eastern Panama, in the collection of

Mr. Herbert W. Brandt. These specimens measure as follows: wing, 381-415 (average, 397.9) mm; tail, 153-172 (165.9); culmen without cere, 21-24 (22.5); tarsus, 76-81 (78.6). Eight specimens from South Carolina, Florida, and Texas measure: wing, 415-444 (average 428.1) mm.; tail, 177-195 (184.7); culmen without cere, 22-24 (23); tarsus, 81-99 (85). Account is not taken of the sex in the case of the measurements, inasmuch as there seems to be no significant sex difference in size in this species. In view of the fact that Todd and Carriker,[30] and Friedmann[31] are inclined to believe that the South American form, *Coragyps atratus foetens*, is not distinguishable from *Coragyps atratus atratus* of North America, because of an insufficient difference in size, comparison of these measurements of Panama birds with those of the North American specimens is rather interesting.

The black vultures of South America as a whole may not be distinguishable from those of North America, as Dr. Friedmann's[32] investigations and the three South American specimens that I have seen would seem to indicate; but the above given measurements show that the Panama birds are certainly subspecifically distinct from the North American form. The question now arises as to whether the Panama black vultures are referable to *C. a. foetens* or are undescribed. Comparison with adequate topotypical material of *C. a. foetens* from Paraguay will be necessary to determine this, and so far I have been able to see but one specimen from that country.

Comparing the wing measurements of Panama black vultures with those given by Friedmann for specimens from Argentina, Chile, Ecuador, and Brazil, namely 412-432 (average 421) mm., together with two specimens from Chile and one from Paraguay in the collection of Herbert W. Brandt which I have examined, with wing measurements of 431-453 (average 439.7) mm., it appears that the birds of southern Central America are smaller than those of South America, at least when the latter are considered as a whole. Furthermore, it seems to lend strength to the suggestion, by Wetmore,[33] of the existence of more than two forms of the black vulture, and the suspicion of Peters[34] that the birds of this species from southern South America are larger than those from the northern part of that continent.

[30]Ann. Carnegie Mus., Vol. XIV, October, 1922, p. 142.
[31]Proc. Biol. Soc. Washington, Vol. 46, October 26, 1933, pp. 187-189.
[32]Proc. Biol. Soc. Washington, Vol. 46, October 26, 1933, pp. 187-188.
[33]Bull. U. S. Nat. Mus., No. 133, February 1, 1926, p. 91.
[34]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 12, October, 1929, p. 415.

Assuming that the southern South American black vultures are larger than those from northern South America and southern Central America, the question then arises, into which group do topotypical Paraguay birds fall? The single Paraguay specimen in the Brandt collection which I have examined measures as follows: wing, 431 mm; tail, 189; culmen without cere, 23; tarsus, 75. These measurements indicate a bird as large as the average of the North American form. However, even if the topotypical *Coragyps atratus foetens* is shown by further material to belong to a larger southern group, it seems that that form might still be maintained as a valid race, which, although very similar to typical *Coragyps atratus atratus* of North America, if it exhibits any tangible character, should be considered distinct from that subspecies because of being completely cut off from it by a still smaller undescribed race in southern Central America and northern South America. If more material from Paraguay is found to exhibit size characters similar to the single individual mentioned above I should have no hesitation in giving a different name to the small Panama bird. Meanwhile, there seems to be no other course open than to refer the Panama birds to *Coragyps atratus foetens* on the basis of distinctly smaller size which is the character designated by supporters of the validity of *C. a. foetens* as distinguishing it from *C. a. atratus*.

On the Azuero Peninsula the black vulture was very common about the plantation, being much more in evidence than the turkey vulture, and replacing that species entirely around the houses. However, the condition was reversed away from civilization, and only one black vulture was seen in the mountains. That one came with the king and turkey vultures to feed on the skinned mammal bodies at Altos Cacao camp.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22026	♂	Paracoté	50 Feet	February 16, 1932

Cathartes aura teter Friedmann. WESTERN TURKEY VULTURE.

From measurements it seems that the single specimen of the turkey vulture obtained must be referred to *Cathartes aura teter*, the race that breeds in western North America.[35] Dr. Herbert Friedmann, the

[35]Friedmann, Proc. Biol. Soc. Washington, Vol. 46, October 26, 1933, pp. 188-189.

describer of *Cathartes aura teter*, has been kind enough to examine the specimen, and he assures me that I am correct in this belief. The only alternative is to consider the bird as representing a transition between *Cathartes aura aura* and a larger South American form such as *Cathartes aura ruficollis*. There is in this example no indication of transition in color toward the black South American birds, however. This specimen measures as follows: wing, 513 mm.; tail, 256; culmen without cere, 23; tarsus, 65.

It is interesing to find *Cathartes aura teter* in Panama, especially in view of Dr. F. M. Chapman's[36] theory that the turkey vultures that, at a certain time in the spring, travel over Barro Colorado Island in Gatun Lake of the Panama Canal Zone, are the migratory birds from the northern part of the range of the species in North America. This is, I believe, the first reported specimen to substantiate that theory.

It is unfortunate that none of the resident turkey vultures were collected, since they were probably encountered fairly regularly throughout our stay in the country. Of course to be absolutely sure that they were residents, one would have to wait until all migrant birds had gone north. This species was less common on the plantation than was the black vulture, *Coragyps atratus foetens*, and the two birds apparently did not associate with one another to any extent. Turkey vultures never came to the feasts of skinned animals that we spread out beside our house on the plantation, and that were well attended by the black vultures. On the other hand, away from the plantation the turkey vulture was more common than the black vulture, and almost entirely replaced the latter species in the mountains, where our offerings were accepted by them readily enough. When a king vulture appeared on the scene, however, the turkey vultures would stand aside until the heavier bird had finished.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22025	♀	Paracoté	Sea Level	March 27, 1932

[36]The Auk, Vol. L, No. 1, January 4, 1933, p. 32.

Elanoïdes forficatus yetapa (Vieillot). SOUTHERN SWALLOW-TAILED KITE.

A pair of these graceful hawks was observed gathering nesting material near our mountain camp at Cavulla. Branches were broken from a dead tree by the birds while on the wing, and carried down the mountainside presumably to a nest located somewhere in the heavy forest of the Rio Negro Valley.

Odontriorchis palliatus (Temminick). BRAZILIAN KITE.

Since I have not had access to adequate material, I have followed Griscom[37] in recognizing only one race of this species. He has examined fifty specimens, including birds from the entire range, and can detect no adequate reason for separating the species into races.

The only specimen seen was collected from a small tree standing by the side of a dried lagoon near the shore of the bay, where the bird was all but concealed by very dense foliage.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22039	♀ im.	Paracoté	Sea Level	February 15, 1932

Accipiter bicolor bicolor (Vieillot). FOUR-BANDED HAWK.

The only individual of this species seen was flying over an open field toward the forest, not more than twenty feet from the ground. Its method of flight was typical of the genus *Accipiter*, direct, and by means of alternate periods of flapping the wings and gliding.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22027	♂ im.	Paracoté	50 Feet	February 7, 1932

Buteo platypterus platypterus (Vieillot). BROAD-WINGED HAWK.

Several broad-winged hawks were seen at various times both at sea level and in the mountains up to 3000 feet.

[37] Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 312.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22028	♀ im.	Altos Cacao	1500 Feet	February 28, 1932
22029	- im.	Paracoté	Sea Level	February 17, 1932

Buteo magnirostris ruficaudus (Sclater and Salvin). RED-TAILED LARGE-BILLED HAWK.

The specimens collected have been compared with adequate series of all the races known to inhabit Panama and have been found to be perfectly typical *Buteo magnirostris ruficaudus*.

By far the commonest hawk in the open scrubby country at sea level and on the cocoanut plantation, this handsomely marked raptor was seen on almost every trip through this type of habitat. As has been noted by other writers[38] who have observed this species in other regions, this large-billed hawk is tame to the point of stupidity. The birds would sit quietly on some cocoanut palm or other small isolated tree, allowing me to walk up to within easy collecting range. This hawk was never seen in the forest or in the open country at higher altitudes.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22030*	♂	Paracoté	Sea Level	February 5, 1932
22031	♂	Paracoté	Sea Level	February 7, 1932
22032	♂	Paracoté	Sea Level	February 8, 1932
22033	♀	Paracoté	Sea Level	February 13, 1932
22034	♂	Paracoté	Sea Level	February 18, 1932
22035	♀	Paracoté	Sea Level	March 21, 1932

Leucopternis albicollis costaricensis W. L. Sclater. COSTA RICAN WHITE-COLLARED HAWK.

The single specimen obtained is not different from birds examined from Costa Rica or those from eastern Panama.

This individual was collected in the bottomland forest at Paracoté. It had apparently been attracted by the cries of a wounded capuchin monkey, as its eyes were intently fixed on this mammal

[38]Peters and Griscom Proc. New Eng. Zoöl. Club, Vol. XI, August 30, 1929, p. 43.

which was lying about a hundred feet away from me and the bird paid no attention to me although it was in the tree directly over my head.

The only other evidence of the presence of this beautiful white hawk was a single wing-quill found in the cloud forest not far from our camp at Cavulla at an altitude of 3000 feet.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22038*	♂	Paracoté	Sea Level	February 5, 1932

Buteogallus anthracinus subtilis (Thayer and Bangs). GORGONA BLACK HAWK.

Current opinions regarding the relationships of the Panama hawks of the genus Buteogallus do not appear to be entirely satisfactory. After a careful consideration of the problem, involving the examination and measuring of 36 specimens of black hawks from Costa Rica and Panama, as well as the type of *Buteogallus anthracinus subtilis*, I have come to the conclusion that there is only one species of this genus represented in Panama, instead of two as is indicated by the recent writings of several authors, notably Peters[39] and Griscom.[40] Notice should be taken here that Chapman pointed out in 1926[41] that intergradation existed between *Buteogallus anthracinus anthracinus* and *B. a. subtilis*; and that Griscom in his "Ornithology of the Republic of Panama",[42] although listing *Buteogallus subtilis* binomially, remarks in a footnote that it is "probably a race of *anthracinus*."

I am unable to find a single character of *B. a. subtilis* which does not show intergradation with *B. a. anthracinus*. In the first place it should be pointed out that all of the supposed characters used to separate *B. a. subtilis* from *B. a. anthracinus* are subject to a great deal of individual variation even in birds of the same age. Secondly, there is a considerable amount of variation in birds of the same region due to age or adventitious effects. Despite these complications, however, there are decided average differeces in birds of the same age which may be correlated with geographic distribu-

[39]Check-list of Birds of the World, Vol. I, 1931, pp. 244-245.
[40]The Auk, Vol. L, No. 3, July 6, 1933, p. 303.
[41]Bull. Amer. Mus. Nat. Hist., Vol. LV, October 1, 1926, p. 233.
[42]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, April, 1935, p. 300.

tion. The most noticeable of these is that of size, but color differences are also important. The following discussion of these characters relates to only adult birds in the black plumage, since I have not seen adequate material to distinguish the races when in juvenal plumage, which varies greatly in birds from the same region.

The width of the median white band on the tail is an extremely variable character, but apparently has some subspecific value, averaging broader in *B. a. anthracinus* than in either *B. a. subtilis* or *Buteogallus anthracinus cancrivorus*. The range of the last form, incidentally, extends into Panama on the Caribbean coast at least as far west as Port Obaldia. The width of the terminal white band on the tail is, except in fresh plumage of no diagnostic value because of the great amount of variation due to abrasion. The buff color of this band was used by Swann[43] as a distinguishing characteristic of *B. a. subtilis*, but here again a great deal of individual variation is found to exist in both *B. a. anthracinus* and *B. a. subtilis*. An examination of the type of the latter form shows that its tail is in molt, and that the old feathers are deeply buff on the tips while in the freshly grown quills this area is pure white. This would seem to indicate that buffiness is an adventitious character. That *B. a. subtilis* seems to have tail tips averaging more deeply buff than *B. a. anthracinus* is possibly due to the fact that the former lives more in the region of tide-water, where, walking about on the mud in search of its favorite food, crabs, it is more liable to soil the tips of its tail-feathers. The supposed characteristic of the duller coloration of *B. a. subtilis* is probably also adventitious, and due to fading; at any rate, some individuals of *B. a. subtilis* are as blackish as typical *B. a. anthracinus*.

In the extent of the rufous barring on the secondaries complete intergradation is shown in individuals of the same age between *B. a. subtilis* and *B. a. anthracinus*, but the former subspecies has on the average more rufous. The type of *Buteogallus anthracinus subtilis*, from Gorgona Island, Colombia, has the most rufous, while the specimens of that race examined from the coast of Costa Rica have the least. Intergradation in this character might also be considered as taking place through *B. a. cancrivorus*, which is intermediate in this respect between *B. a. anthracinus* and *B. a. subtilis*.

The character of less white at the base of the primaries used by Swann[43] to separate his supposed race *Urubitinga* [=*Buteogallus*] *anthracina bangsi* from the Pearl Islands, is valid in *B. a. subtilis*, but complete intergradation in this respect with *B. a. anthracinus* is found.

Size is the most reliable character separating *B. a. subtilis* from *B. a. anthracinus*, the former averaging smaller. Intergradation in size between *B. a. subtilis* and *B. a. anthracinus* in Costa Rica and Panama, and between *B. a. subtilis* and *B. a. cancrivorus* in Panama is amply shown, however, by the following tables. Measurements of specimens in the United States National Museum taken by Dr. Herbert Friedmann were kindly supplied by that institution and are included in this table. Measurements of specimens in the National Museum from Tlalixtaquilla, Guerero; Puerto Angel, Oaxaca; San Benito and El Carrizal, Chiapas were omitted from the table because, although they seem to be those of *B. a. subtilis*, the specimens have not been examined with respect to other characters. Measurements of specimens (not examined for other characters) from Pigres on the Gulf of Nicoya, Costa Rica were included under *B. a. subtilis* on the basis of the geographic position of that locality. It is quite possible, however, that the larger specimens allegedly from Pigres were taken sufficiently far from the Pacific coast to be within the range of *B. a. anthracinus*.

TABLE V

Measurements of Subspecies of Buteogallus anthracinus

Buteogallus anthracinus anthracinus

Sex	*Locality*	*Wing*	*Tail*	*Culmen without Cere*	*Tarsus*
♂	Fort Clark, Texas	360	207	26.5	88
♂	Santa Efigenia, Oaxaca, Mexico	376	214	27	88.5
♂	Rivera, Northern Vera Cruz, Mexico	364	200	25.5	
♂	Chihuahua, Mexico	377	209	28	83
♂	San Louis Mountains, Chihuahua, Mexico	390	207		76
♂	Galindo, Tamaulipas, Mexico	375	208	25	90
♂	Changuinola Canal, Bocas Del Toro, Panama	366	205	28	89
♂	Western River, Bocas Del Toro, Panama	377	206	28	89
♂	Banana River, Bocas Del Toro, Panama	360	195	26	92
	Average Male	370.6	205.7	26.8	86.9
♀	Starr County, Texas	375	209	25	89
♀	Mirador, Vera Cruz, Mexico	371	203	26	89
♀	Acapulco, Guerrero, Mexico	384	248	28	94

[43]Monograph Birds of Prey, Vol. I, Part VIII, January, 1930, p. 460.

Sex	*Locality*	*Wing*	*Tail*	*Culmen without Cere*	*Tarsus*
♀	Cajon, Bonita Creek, Sonora, Mexico	389	233	28.5	87
♀	La Ceiba, Honduras	379	216.5	28.5	92
♀	Penate, Guatemala	367	207	28	89.5
♀	Talamanca, Costa Rica	383		28	90
♀	Cerro Santa Maria, Costa Rica	401	230	27	94
♀	Bolson, Costa Rica	374	212	29	95
♀	Guayabo, Costa Rica	400	229	30.5	92
	Average Female	382.3	220.8	27.9	91.2

Buteogallus anthracinus subtilis

Sex	*Locality*	*Wing*	*Tail*	*Culmen without Cere*	*Tarsus*
♂	Pigres, Nicoya, Costa Rica	354	196	28	
♂	Paquera, Nicoya, Costa Rica	369	205	27	89
♂	Paquera, Nicoya, Costa Rica	367	203	27	90
♂	Ballena, Guanacaste, Costa Rica	365	200	27	89
♂	Humo, Guanacaste, Costa Rica	355	197	28	87
♂	I. del Caño, Guanacaste, Costa Rica	353	186	26	82
♂	I. del Caño, Guanacsate, Costa Rica	340	185	26	91
♂	I. del Caño, Guanacaste, Costa Rica	342	170	25	85
♂	Azuero Peninsula, Panama	337	182	23	81
♂	Azuero Peninsula, Panama	330	174	25	80
♂*	Pearl Islands, Panama	368	192	29	89
♂†	Gorgona Island, Colombia	343	183	28	85
	Average Male	351.9	189.4	26.6	86.2
♀	Pigres, Nicoya, Costa Rica	355	197	27	84
♀	Pigres, Nicoya, Costa Rica	380	218	28	88.5
♀	Pigres, Nicoya, Costa Rica	377	210	29	91
♀	Pigres, Nicoya, Costa Rica	368	217	28	85
♀	Ballena, Guanacaste, Costa Rica	367	205	28	89
♀	Punta Jiminez, Pen. de Oso, Costa Rica	355	185	25	90
♀	I. del Caño, Costa Rica	349	185	28	88
♀	I. del Caño, Costa Rica	337	182	26	88
♀	I. del Caño, Costa Rica	330	173	27	91
	Average Female	357.6	196.9	27.3	88.3

Buteogallus anthracinus cancrivorus

Sex	*Locality*	*Wing*	*Tail*	*Culmen without Cere*	*Tarsus*
♂	Port Obaldia, Panama	365	195	26	92
♂	Port Obaldia, Panama	361	197	25	88
♂	Port Obaldia, Panama	355	192	26	83
♂	Port Obaldia, Panama	370	195	27	93
♂	Port Obaldia, Panama	352	187	27	81
♂	Port Obaldia, Panama	363	205	27	89
	Average Male	361.0	196.8	26.3	87.7
♀	Port Obaldia, Panama	367	206	29	90
♀	Port Obaldia, Panama	367	205	29	87
♀	Port Obaldia, Panama	378	205	28	88

Sex	Locality	Wing	Tail	Culmen without Cere	Tarsus
♀	Port Obaldia, Panama	367	202	28	88
♀	Port Obaldia, Panama	360	202	28	84
♀	Port Obaldia, Panama	367	210	28	91
♀	St. Vincent Island, West Indies	378	207	27	92
	Average Female	369.1	207.3	28.1	88.6

*Type of *Urubitinga anthracina bangsi.*
†Type of *Urubitinga subtilis.*

The most reliable difference between *B. a. subtilis* and *B. a. cancrivorus* is the lack of buff and white bases of the anterior dorsal feathers in the adult birds of the former race, in which respect it is like *B. a. anthracinus*. *B. a. cancrivorus* does average larger than *B. a. subtilis*, but the overlapping in this respect is considerable.

On the basis of the characters mentioned above, a tentative delineation of the ranges of the subspecies of *Buteogallus anthracinus* might be suggested as follows:

Buteogallus anthracinus anthracinus.—Southern Arizona and central southern Texas to western Panama (Almirante Bay) excepting edge of Pacific coast line from southern Mexico southeastward.

Buteogallus anthracinus cancrivorus.—Caribbean coast of Venezuela together with Trinidad and the nearest of the Lesser Antilles (at least north to St. Vincent), west along the Caribbean coast of Colombia to eastern Panama (Port Obaldia).

Buteogallus anthracinus subtilis.—Pacific coast and islands of Central and South America from Guerrero, Mexico to Ecuador.

A peculiarity in the range of *B. a. subtilis* is that it seems to be confined almost entirely to the narrow belt of coastal mangrove swamps of the Pacific coast and islands, while that of *B. a. anthracinus* includes the upland as well as the Caribbean coast region. In Costa Rica, as soon as the immediate vicinity of the Pacific coast is left, the birds approach *B. a. anthracinus* in appearance very rapidly, as is shown by the specimen of that subspecies from Bolson, Costa Rica, which is only 20 miles inland at the base of the Peninsula de Nicoya.

The above given statement of ranges does not take into account South American specimens which authors have referred to *B. a. anthracinus*. It is possible, of course, that the range of this form runs through the interior of Panama into the interior of Colombia, but, having seen no specimens from these regions, the writer cannot say whether or not this is the case. If specimens exist from these areas and were examined in the light of possible intergradation between *B. a. subtilis* and *B. a. cancrivorus*, it might be found that this would be a better explanation of their status than referring them to *B. a. anthracinus*.

The Pearl Islands specimen used by Swann[44] as the type of *Urubitinga anthracinus bangsi*, as mentioned above, was referred to *Buteogallus anthracinus anthracinus* by Peters.[45] The writer has examined this bird and agrees that it resembles that form except in length of tail and in the amount of white on the primaries, in which respects it is nearer to *B. a. subtilis*. Therefore he prefers to consider the type of *Urubitinga anthracina bangsi* a large example of *Buteogallus anthracinus subtilis*.

The Gorgona black hawk was observed on several occasions on the Azuero Peninsula along tidal ditches and at the edge of the mangrove swamp. On one of these occasions an individual was standing on a small plank bridge over a tidewater irrigation ditch among the cocoanut palms. The bird was eating a crab, and allowed a rather close approach before flying away and leaving the shell of the crab for examination.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22036	♂	Paracoté	Sea Level	February 10, 1932
22037	♂	Paracoté	Sea Level	March 29, 1932

Herpetotheres cachinnans cachinnans (Linnaeus).
LAUGHING FALCON.

The 2 specimens collected have been compared with 8 specimens from the Pacific coast of Costa Rica. Six of the Costa Rica birds are more whitish below and 2 are of a deeper buff than our specimens.

[44]Monograph Birds of Prey, Vol. I, Part VIII, January, 1930, p. 460.
[45]Check List of Birds of the World, Vol. I, October 6, 1931, p. 244.

No topotypical specimens of *Herpetotheres cachinnans cachinnans* or *Herpetotheres cachinnans fulvescens* were seen. However, Griscom[46] seems to have worked out the status of the subspecific relationships of this hawk about as well as is possible with a species so subject to individual variation, and I here abide by his conclusions in referring our specimens to the typical form *H. c. cachinnans*.

The 2 specimens collected were the only examples of this bird seen. Both were sitting quietly on the lower limbs of trees at the forest margin when discovered, and allowed a rather close approach without showing any sign of alarm.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22043	♀	Paracoté	Sea Level	February 15, 1932
22044	♀	Paracoté	Sea Level	March 27, 1932

Daptrius americanus guatemalensis (Swann). NORTHERN RED-THROATED CARACARA.

The 2 males that we obtained have wing measurements of 357 mm. and 363 mm. respectively and thus seem to be referable to the northern form *Daptrius americanus guatemalensis*. Comparison was made with a male of *D. a. guatemalensis* from Costa Rican and a female of *D. a. americanus* from French Guiana the wings of which measure 365 mm. and 320 mm. respectively. Furthermore, the dimensions of our birds fall well within the limits given by Peters[47] for *D. a. guatemalensis*, and are greater than the maximum given by that author for *D. a. americanus*.

The 2 specimens were the only individuals of this species seen. They were discovered by the terrific din that they were making in the forest. When one of the birds was shot the other flew over, squawking raucously, and began hopping excitedly from one branch to another so close to me that I hesitated to shoot for fear of damaging it for a specimen.

[46]Bull. Amer. Mus. Nat. Hist., Vol. LXIV, May 7, 1932, pp. 159-161.
[47]Proc. Biol. Soc. Washington, Vol. 44, February 21, 1931, p. 25.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22040*	♂	Paracoté	Sea Level	March 24, 1932
22041*	♂	Paracoté	Sea Level	March 24, 1932

*Bill yellow. Cere bluish gray. Feet, iris, and bare skin of head red. Claws black.

Milvago chimachima cordatus Bangs and Penard. PANAMA CARACARA.

The single specimen obtained was the only example of the species seen. It was observed perched on the top of a cocoanut palm beside our house on the plantation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22042	♂(?) juv.	Paracoté	50 Feet	February 19, 1932

Falco albigularis albigularis Daudinn. WHITE-THROATED BAT FALCON.

The only record for this species is 1 specimen collected at the outer edge of the mangrove swamp fringing Montijo Bay.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22045*	♀	Paracoté	Sea Level	April 2, 1932

*Cere and bare skin around eye yellowish green.

Crax rubra rubra Linnaeus. RED CURASSOW.

It seems obvious from an examination of the literature that the systematic status of the species *Crax rubra* is not well understood. With only one pair of birds available the writer can contribute little to its elucidation except to describe the appearance of these 2 birds with the hope that in the future this may be of assistance to some worker who attempts a revision of the forms of this group. Meanwhile, I shall follow Miller and Griscom[48] who seem to have worked out the status of the Panama examples of this species about as well as is possible in such a variable form and with but few specimens available. They refer Panama birds to *Crax globicera* which

[48]Amer. Mus. Novit., No. 25, December 9, 1921, pp. 7-8.

is shown by Peters[49] to be a synonym of *Crax rubra*. Our specimens may be described as follows:

Adult male: head, neck, back, wings, tail, chest, and thighs, black with a slight greenish gloss on the back, wings, chest, and upper surface of the tail; middle of breast brownish black; posterior flanks, abdomen, and under tail-coverts, pure white; bill pale buff at tip, with a dark brown band around the middle (at nostril), yellow at base, with yellow caruncle on the base of the culmen. Length of wing, 392 mm.; tail, 327; exposed culmen, 56; tarsus, 126.

Adult female: head and neck, black barred with white, the long crest feathers with a single white band, shorter feathers of neck and throat usually with two white bands; anterior back and chest, deep chestnut; remainder of back and chest and wings, chestnut; primaries and secondaries barred and spotted with black; breast pale chestnut on the sides, shading to ochraceous tawny in the center; abdomen ochraceous buff; upper surface of tail chestnut barred with black and pale ochraceous buff; under surface of tail brownish black with traces of chestnut at base and tip, crossed by pale ochraceous buff bars flecked with black; bill buffy at tip, brown at base. Wing, 379 mm.; tail, 304; exposed culmen, 46; tarsus, 116.

It is worthy of note that the male does not have a white tip to the tail; also that the female, although apparently fully adult in other respects, does have distinct black barring on the wings. The white tip on the tail of the male and the lack of barring on the wings were characters used by Ogilvie-Grant[50] in separating *Crax panamensis* from *Crax globicera*.

The two birds listed below were the only examples seen. They were evidently a pair as they were found together on the ground beside a spring in the deep forest at Cerro Viejo Camp. They ran along the ground together when disturbed by my approach, not attempting to fly until I discharged my gun. When the female was shot the male flew into the lower branches of a tree near by, where he stood craning his neck in the direction of his fallen mate until he also was collected. This seemed like a remarkable exhibition of tameness for a species so persistently hunted for food by the

[49]Check List of the Birds of the World, Vol. II, June 15, 1934, p. 12.
[50]Catalogue of Birds in the British Museum, Vol. XXII, December, 1893, pp. 479-480.

natives as is this species. It is called "pavo real" by the natives to distinguish it from the more common "pavo" (*Penelope purpurascens*).

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22046*	♂	Cerro Viejo Camp	2000 Feet	March 9, 1932
22047	♀	Cerro Viejo Camp	2000 Feet	March 9, 1932

*Caruncle and base of bill lemon yellow.

Penelope purpurascens aequatorialis Salvadori and Festa. EQUATORIAL GUAN.

The 3 specimens collected are not distinguishable from 2 from western Ecuador in the collection of Mr. H. B. Conover, and thus can be considered typical of the race *Penelope purpurascens aequatorialis*.

The "pavo", as the natives called this species, was much sought after as food in Panama, and so was much more abundant away from than near the plantation. It was encountered fairly regularly in the humid tropical forests on the mountain slopes, particularly at Cerro Viejo camp where a flock of 7 birds flew through camp one day, and where on another occasion a group of five was observed in one tree, feeding on its fruit. It was not observed in the cloud forest at 3000 feet elevation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22048*	—	Paracoté	Sea Level	February 16, 1932
22049	—	Mariato River Camp	250 Feet	February 26, 1932
22050	♀	Paracoté	Sea Level	March 19, 1932

*Bare skin on throat brick red.

Ortalis garrula olivacea, subsp. nov. AZUERO GUAN.

Subspecific Characters.—Similar to *Ortalis garrula cinereiceps* but somewhat larger; distinctly darker olive brown on back, wings, upper tail-coverts, and chest; tail darker, greenish black; primaries more deeply rufescent. Very different from *Ortalis garrula frantzii*, being distinctly larger, much paler throughout, and more olive (less reddish) brown.

Measurements.—Adult male (4 specimens from the Azuero Peninsula): wing, 212-227 (average, 218.5) mm.; tail, 222-240 (230.5); exposed culmen, 25-26 (25.8); tarsus, 65-69 (67.3). Adult female (1 specimen from the Azuero Peninsula); wing, 205; tail, 228; exposed culmen, 26; tarsus, 64.

Type.—Adult male, No. 22052, Cleveland Museum of Natural History; Paracoté, elevation 50 feet, eastern shore of Montijo Bay, 1 mile south of the mouth of the Angulo River, Veraguas, Panama; February 10, 1932; John W. Aldrich, original number 1683.

Geographic Distribution.—As far as is known, confined to the Azuero Peninsula, Southern Veraguas, Panama. Possibly occuring also in other parts of the Pacific coast of Veraguas, and Chiriqui, Panama.

Remarks.—Peters[51] gives as the type locality of *Ortalis garrlau cinereiceps* (*Ortalida cinereiceps* G. R. Gray), " 'north-west coast of America' error = Pearl Islands (?). Type collected by Kellett and Wood." Mr. Peters writes me as follows, "The question mark after Pearl Islands in my second volume under *Ortalis g. cinereiceps* is meant to express doubt as to whether the type of *Ortalida cinereiceps* Gray came from the Pearl Islands. The type was collected by Kellett and Wood and most of Kellett and Wood's Central American birds probably came from the Pearl Islands, but some of them may possibly have come from Panama. The Herald, under Captain Kellett, was at the Pearl Islands and Panama, March 23-April 16, 1846. See Seeman's narrative of the Voyage of the Herald, Vol. 1."

Mr. N. B. Kinnear has kindly examined for me the type of *Ortalida cinereiceps* in the British Museum, and writes, "I am afraid it is not possible to say where the type of *O. cinereiceps* came from as it has no proper collector's label.

"Of the three Panama birds we have, only one has an exact locality, Paraiso Station, but in color they are all the same, and so too are our Veraguas skins. I cannot say that the type of *O.cinereiceps* differs from these birds."

In view of the apparent impossibility of determining positively the exact source of the type specimen of *Ortalis garrula cinereiceps*

[51]Check List of Birds of the World, Vol. II, June 15, 1934, p. 20.

and since it seems desirable to have the type locality fixed in view of the presence of more than one geographic race of the species in Panama, I designate San Miguel, Pearl Islands, Bay of Panama, as the type locality of *Ortalis garrula cinereiceps* (Gray). This action is in accordance with the commonly accepted procedure in designation of type locality, since Kellet and Wood are known to have visited this archipelago and could have obtained the bird there.

Examining a series of specimens from several localities in Panama and Costa Rica the writer found that a bird from Boruca, Costa Rica, in the Museum of Comparative Zoölogy collection, although slightly darker and more rufescent above than 3 specimens from the Pearl Islands is closer to these birds than to those from the Azuero Peninsula and should doubtless be referred to *O. g. cinereiceps*. This fact together with the findings of Thayer and Bangs,[52] and Kinnear (see above) that examples from the Pacific side of the Canal Zone, Veraguas (interior) and Chiriqui are inseparable from the Pearl Island birds, leads me to believe that the range of *O. g. cinereiceps* includes not only the Pearl Islands, but also the mainland of Panama and Costa Rica, at least on the Pacific side, from the Canal Zone westward to Boruca, but omitting the Azuero Peninsula which is occupied by *O. g. olivacea*. Eight specimens from eastern Costa Rica in the collection of Mr. H. B. Conover are much smaller and darker than Pearl Island examples and are taken to be representative of *Ortalis garrula frantzii*. Although no topotypical specimens of this race have been seen, 5 of the 8 specimens examined were from Jiminez and Guapiles which are near Bonilla, from which region came specimens referred by Miller and Griscom[53] to *Ortalis garrula saturata*. This form has been listed by Peters[54] as a synonym of *O. g. frantzii*.

I am unable satisfactorily to place 2 specimens in the collection of the U. S. Biological Survey from Gatun on the Caribbean side of the Canal Zone. They are distinctly darker and more rufescent, both above and below, than typical *O. g. cinereiceps* from the Pearl Islands, being in fact almost directly intermediate in color between them and the series of *O. g. frantzii* from western Costa Rica. They differ from the Azuero Peninsula series of *O. g. olivacea* chiefly in being more rufescent, particularly on the chest, and of a somewhat

[52]Bull. Mus. Comp. Zoöl., Vol. XLVI, No. 8, September, 1905, p. 145.
[53]Amer. Mus. Nat. Hist. Novit., No. 25, December 9, 1921, pp. 1-2.
[54]Check List of Birds of the World, Vol. II, June 15, 1934, p. 20.

darker gray on the head. No specimens of *Ortalis garrula mira* from the Caribbean coast of eastern Panama have been seen, so it cannot be said what relationship the Gatun specimens bear to this form. If a larger series of specimens from the Caribbean slopes of central and western Panama should show the bird from this region to be distinct, it would be another case like those of *Tinamus major* and *Crypturornis soui* in which the comparatively tiny geographic area of the Canal Zone is favored with 2 races of the same species, one on the more humid Caribbean side and the other on the less humid Pacific side.

The Azuero guan was not uncommon along the edge of the forest adjoining the cocoanut plantation at Paracoté. A group of 6 birds was observed on one occasion noisily feeding in certain trees which were loaded with ripe fruit. The loud calls of these birds were frefuently heard at dawn and sunset, at which times they apparently vied with the howler monkeys for dominance of sound. The "faisano," as the natives called this little guan, was entirely absent from the deep forest, where it was replaced by the big crested guan (*Penelope purpurascens*).

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22051	♂	Paracoté	50 Feet	February 7, 1932
22052	♂	Paracoté	50 Feet	February 10, 1932
22103	♀	Paracoté	50 Feet	February 10, 1932
22054	♂	Paracoté	50 Feet	March 27, 1932
22055	♂	Paracoté	50 Feet	March 27, 1932

Aramides cajanea cajanea (P. L. S. Müller). CAYENNE WOOD RAIL.

The single specimen obtained has been compared with examples of *Aramides cajanea latens* from the Pearl Islands and with *Aramides cajanea cajanea* from eastern Panama, and seems to be typical of the latter form. The colors of the soft parts as noted from the newly killed bird are: skin around eye, iris, corners of mouth and feet, red; inner half of bill brownish yellow; outer half pale bluish green.

These interesting rails were seen on a few occasions along the tidal drainage ditches on the cocoanut plantation at or near sea

level. Their weird cries were heard frequently at night. Our guide, P. A. Davies, a resident of Santiago, Veraguas, and a better than average observer of wild life, told us that the curious noise was made by two birds standing face to face and calling in unison, accompanying the sound by vigorously raising and lowering their heads. The cry is loud and might be described as a series of short gurgling laughs. This call was heard once at dusk at an altitude of 3000 feet in the mountains, coming from the vicinity of a small stream bed at the edge of the forest.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22056	♂	Paracoté	50 Feet	April 2, 1932

Charadrius semipalmatus Bonaparte. SEMIPALMATED PLOVER.

The little semipalmated plover was a very common constituent of the droves of shore-birds that paraded up and down the mud-flats bordering Montijo Bay.

Squatarola squatarola (Linnaeus). BLACK-BELLIED PLOVER.

A few black-bellied plovers were detected among the shore-bird aggredations that swarmed over the mud bars at the mouth of the estero at Paracote. This species was still present on March 29, 1932, which was the last day of collecting in that habitat.

Numenius hudsonicus Latham. HUDSONIAN CURLEW.

Several Hudsonian curlews were seen on March 29, 1932 on the mud-flats bordering Montijo Bay, which were exposed at low tide.

Actitis macularia (Linnaeus). SPOTTED SANDPIPER.

Several spotted sandpipers were seen on February 13, 1932 on the beach at Paracoté. A single individual was seen on February 20 in a small gravel pit in a pasture at Paracoté. Several more were seen teetering along the sand-bars among the rocks on the Mariato River 10 miles east of Montijo Bay during our stay in camp on that river, February 21-26.

Catoptrophorus semipalmatus, (subsp.?). WILLET.

A few willets were present on the mud-flats bordering Montijo Bay on March 29, 1932. Failure to obtain specimens makes it impossible to state to which subspecies these individuals should be referred.

Tringa solitaria, (subsp.?). SOLITARY SANDPIPER.

Several individuals of this species were noted on the beach at Paracoté. As no specimens were collected, it is impossible to say to which subspecies they belonged.

Totanus melanoleucus (Gmelin). GREATER YELLOW-LEGS.

The greater yellow-legs was a common species among the large shore-bird gatherings on the sand-bars at the mouth of the estero at Paracoté.

Limnodromus griseus, (subsp.?). DOWITCHER.

Several dowitchers were seen among other shore-birds on the mud-flats of Montijo Bay on March 29, 1932. Since no specimens were collected, however, it is impossible definitely to allocate them subspecifically.

Ereunetes pusillus (Linnaeus). SEMIPALMATED SANDPIPER.

Large numbers of these little sandpipers were seen on several occasions both on the beach at Paracoté and on the extensive mud-flats at the mouth of the Paracoté estero.

Columba speciosa Gmelin. SCALED PIGEON.

A single specimen of this species, called "paloma del monte" by the natives, collected on the cocoanut plantation, was the only individual observed on the entire trip. Color notes on the soft parts of this specimen are as follows: bill red, except tip, which is pale horn; feet purplish gray, skin around eye purplish red.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22057	♂	Paracoté	50 Feet	March 28, 1932

Columba rufina pallidicrissa Chubb. PALE-VENTED PIGEON.

Two specimens, taken in the vicinity of the cocoanut plantation by P. A. Davies were the only ones recorded for the entire trip.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22058*	♂	Paracoté	Sea Level	March 28, 1932
22059	♂ im.	Paracoté	Sea Level	March 28, 1932

*Skin around eye and feet, purplish red.

Columbigallina minuta elaeodes (Todd). PLAIN-BREASTED GROUND DOVE.

From an examination of 47 specimens from British Honduras, Costa Rica, Panama, Colombia, Venezuela, Peru, and Bolivia, it seems evident that there is more geographic variation in this species than is shown by the currently recognized nomenclature. In the first place, two males and one female from Lima, Peru, in the Carnegie Museum are so very distinctly paler than a series of *Columbigallina minuta minuta* from Venezuela that it seems desirable to consider them as representing a distinct subspecies for which the name of *Columbigallina minuta amazilia* (Bonaparte) is available, according to Todd[55] who also noted this paler condition in a specimen from Lima. A single male from the Department of Vera Cruz, Bolivia, is intermediate in pallor between Venezuela and Peru birds, but has more white on the greater coverts than either.

The difference between *C. m. minuta* and *C. m. elaeodes* is very well marked in the series examined; the 14 specimens from Costa Rica, including 4 from Buenos Aires (topotypical *C. m. elaeodes*), being approximately as much darker throughout than the Venezuelan birds as the latter are darker than the specimens from Lima,Peru.

There also seem to be less conspicuous geographic differences among the Central American examples. Seven birds from the Pan-

[55]Ann. Carnegie Mus., Vol. VIII, Nos. 3-4, March, 1913, pp. 557-578.

ama Canal Zone average darker and more brownish (less grayish) olive brown above, with the olive brown patch on the crown more extensive than in Costa Rica specimens.

The single adult male from the Azuero Peninsula is paler than any other Central American bird seen. In fact it is as pale as the average of the Venezuela specimens, but more brownish, (less grayish) olive brown above and has the under tail-coverts much more buffy. The two females from the Azuero Peninsula, however, are as dark as the Canal Zone birds and like them more brownish than the Costa Rica specimens.

Three specimens in the Carnegie Museum from All Pines, British Honduras, are larger and darker than Costa Rica examples, and like the Canal Zone specimens have a much more extensive crown patch. They are like the Costa Rica birds, however, in having a more grayish cast to the olive brown above. Below they have a more grayish appearance than any of the other examples of this species examined. Guatemala and British Honduras birds have been named by Griscom *Columbigallina minuta interrupta*.

The Canal Zone birds like those from Guatemala and British Honduras may eventually prove to be worthy of separation from *C. m. elaeodes*, but, at the present time, the writer hesitates to recommend such a course because the considerable amount of individual variation makes it imperative to have larger series than have been available before the true relationships can definitely be determined.

Field experience with this species on the Azuero Peninsula proved it to be not nearly as common as the slightly larger ruddy ground dove (*Columbigallina rufipennis*). In fact it was seen only in a rather restricted area of low brushy growth among the cocoanut palms on the plantation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22074	♀	Paracoté	Sea Level	February 13, 1932
22075	♂	Paracoté	Sea Level	February 17, 1932
22076	♀	Paracoté	Sea Level	February 17, 1932
22077	♀ juv.	Paracoté	Sea Level	March 21, 1932

Columbigallina rufipennis rufipennis (Bonaparte). RUDDY GROUND DOVE.

Although presenting considerable individual variation in color, both in males and in females, the specimens of *Columbigallina rufipennis rufipennis* that we obtained on the Azuero Peninsula show no average difference from examples from surrounding regions of Central America. They have not, however, been compared with topotypical specimens from Carthagena, Colombia.

This little ground dove was one of the commonest species about the houses, in the pastures, and among the cocoanut palms on the plantation. Small flocks of from six to a dozen birds were frequently seen in our dooryard, walking about briskly with the characteristic head-bobbing motion of the pigeon tribe. They seemed to be endowed with a great amount of nervous energy and were constantly on the move.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22069	♂	Paracoté	50 Feet	February 7, 1932
22070	♂	Paracoté	50 Feet	February 10, 1932
22071	♀	Paracoté	50 Feet	February 10, 1932
22072	♀	Paracoté	50 Feet	March 21, 1932
22073	♂	Paracoté	50 Feet	March 29, 1932

Claravis pretiosa pretiosa (Ferrari-Perez). BLUE GROUND DOVE.

The single female specimen collected was the only example of this species noted on the entire trip.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22068	♀	Mariato River Camp	250 Feet	February 24, 1932

Leptotila verreauxi verreauxi (Bonaparte). VERREAUX DOVE.

Our Azuero Peninsula series of 5 birds is very little more brownish than a specimen from Cayenne, French Guiana; in fact, it is closer to that specimen than to two birds from Divala and Bugaba, Western Panama. These last two specimens are decidedly more brownish

above than the Guiana specimen and so show a tendency to intergrade with *Leptotila verreauxi riottei* of eastern Costa Rica.

The Verreaux dove was a very common bird about the houses, among the cocoanut palms, and in more open situations about the plantation. It was entirely absent from the heavy forest away from the plantation and from the mountains.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22062*	♂	Paracoté	50 Feet	February 13, 1932
22063*	♀	Paracoté	50 Feet	February 13, 1932
22064*	♀	Paracoté	50 Feet	February 14, 1932
22065	♂	Paracoté	50 Feet	March 22, 1932
22066	♂	Paracoté	50 Feet	March 28, 1932

*Feet red. Skin around eye grayish blue. Iris orange.

Leptotila plumbeiceps malae Griscom. CAPE MALA DOVE.

The two specimens collected very well substantiate the characters of this form which was described by Griscom[56] from a single female collected by Rex Benson at Cerro Montuosa, not more than 10 miles from where our birds were taken. Our specimens are therefore virtually topotypes, and their capture exactly tripled the number of existing examples of this form in collections.

This Cape Mala dove is a bird of the deep tropical rain forest, where it was occasionally flushed with a loud partridge-like whir of wings from the trails ahead of us as we walked along. It was not common anywhere.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22060*	♀	Mariato River Camp	250 Feet	February 23, 1932
22061	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932

*Feet red.

Oreopeleia montana (Linnaeus). RUDDY QUAIL DOVE.

The only one of this species seen was a female taken in the forest at 3000 feet elevation. The interesting colors of the unfeathered parts are as follows: base of bill red; feet, with scales red, skin be-

[56]Amer. Mus. Novit., No. 280, September 10, 1927, p. 4.

tween scales flesh color; iris golden brown (same color as feathers around eye); bare skin around eye gray, with reddish on eyelids in front of and under eye.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22067	♀	Cerro Viejo, Cavulla	3000 Feet	March 14, 1932

Aratinga ocularis (Sclater and Salvin). VERAGUA PAROQUET.

Our series does not differ appreciably in size or color from specimens taken in other parts of the limited range of this species.

The Veragua paroquet was a common bird on the plantation, moving in flocks of from two to a dozen birds, and frequenting the scrubby cutover land. Toward evening the flocks would fly back and forth with considerable vocal clatter.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22083	♂	Paracoté	50 Feet	March 22, 1932
22084	♂	Paracoté	50 Feet	March 22, 1932
22085	♂	Paracoté	50 Feet	March 22, 1932
22086	♀	Paracoté	50 Feet	March 22, 1932
22087	♀	Paracoté	50 Feet	March 22, 1932
22088	—	Paracoté	50 Feet	March 22, 1932

Brotogeris jugularis jugularis (Müller). TOVI PAROQUET.

This was a common bird on the plantation, traveling about in large bands, and feeding usually in the tops of certain tall trees at the edge of the forest where it found small red fruit much to its liking. When fired at repeatedly, the whole flock would fly off noisily each time, then circle around and come back to the same tree and start feeding again.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	Elevation	*Date*
22089	♂	Paracoté	Sea Level	March 27, 1932
22090	♂	Paracoté	Sea Level	March 27, 1932
22091	♂	Paracoté	Sea Level	March 27, 1932
22092	♀	Paracoté	Sea Level	March 27, 1932
22093	♀	Paracoté	Sea Level	March 27, 1932
22094	♀	Paracoté	Sea Level	March 27, 1932
22095	♀	Paracoté	Sea Level	March 27, 1932
22096	♀	Paracoté	Sea Level	March 27, 1932
22097	♀	Paracoté	Sea Level	March 29, 1932

Amazona autumnalis salvini (Salvadori). SALVIN PARROT.

Two of the 4 specimens collected have a trace of yellow on the lores which indicates a slight tendency toward intergradation with *Amazona autumnalis autumnalis*.

This was the commonest parrot on the plantation. Groups of two or three individuals would start flying late in the afternoon and would course back and forth over the treetops, giving vent to raucous calls as they flew. Occasionally individuals would come into the orange trees earlier in the day and feed on the ripening fruit. At such times they were very quiet. Sometimes birds of this species would be frightened by some one from certain fruit-bearing trees on the edge of the forest. On such occasions the birds would invariably wait until he had passed the tree, when they would fly off with loud cries, but always keep a screen of foliage between themselves and the intruder until well out of range. Salvin parrots were shyer and more difficult to collect than almost any other species encountered on the plantation. They were absent from the heavy forest and mountain regions visited.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22078	♂	Paracoté	50 Feet	February 10, 1932
22079*	♂	Paracoté	50 Feet	February 18, 1932
22080	♂	Paracoté	50 Feet	March 24, 1932
22081	♂	Paracoté	50 Feet	March 27, 1932

*Iris orange.

Pionus menstruus (Linnaeus). BLUE-HEADED PARROT.

Only 1 individual of the blue-headed parrot was seen on the entire trip. It was taken at the edge of a clearing in the forest at an altitude of 1500 feet.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22082	♂	Altos Cacao	1500 Feet	March 2, 1932

Piaya cayana incincta Griscom. PANAMA SQUIRREL CUCKOO.

The 2 specimens obtained have been compared with 1 nearly topotypical example of *Piaya cayana incincta* from Port Obaldia and

8 supposedly typical specimens of *Piaya cayana thermophila* from Mexico: 3 from Vera Cruz, 1 from Tabasco, 1 from Chaiapas, 1 from Campeche, and 2 from Oaxaca.

The Azuero Peninsula birds are decidedly nearer *P. c. incincta* than to *P. c. thermophila* in the following respects: generally darker coloration above, with a more pronounced violaceous gloss on the back, wings, and upper surface of the tail; more blackish abdomen and under tail-coverts; longer, stouter, and more highly arched bill; and narrower black tips on the tail-feathers.

The larger and more highly arched bill was not noted by Griscom[57] as one of the distinguishing characters of *P. c. incincta*, but was mentioned by Van Rossem[58] as characteristic of Panama and Costa Rica specimens. The series available shows this difference to be one of the most pronounced and constant of those separating the 2 forms. The color of the under surface of the rectrices, on the other hand, although used by Griscom[57] as one of the most important characters of *P. c. incincta*, is found to be the one most subject to individual variation and of no value in separating the 2 Azuero Peninsula birds from the Mexican series, since they are identical in this respect. In fact, one of the Azuero specimens had median rectrices with under surfaces as blackish as the extreme of the 3 specimens from Vera Cruz.

Although the Azuero Peninsula specimens are definitely referable to *P. c. incincta* they are by no means typical of that form. They are somewhat intermediate in every character mentioned between the Obaldia specimen and the Mexican series. Two specimens from western Costa Rica (El Pozo and El General) are almost exactly intermediate between the representatives of these 2 races, but seem a shade nearer *P. c. incincta* on the basis of size of bill, and coloration of upper parts.

The 2 specimens listed below were the only ones seen on the trip. One was taken at the edge of the forest on the plantation and the other in a similar situation on the ridge at Altos Cacao. My attention was attracted to the latter bird by its extremely squirrel-like scolding notes.

[57]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 324.
[58]Trans. San. Diego Soc. Nat. Hist., Vol. VI., No. 12, September 30, 1930, p. 210.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22098	♂	Paracoté	Sea Level	February 11, 1932
22099	♀	Altos Cacao	1500 Feet	March 2, 1932

Crotophaga sulcirostris sulcirostris Swainson. GROOVE-BILLED ANI.

This was a very common species in the low, coastal, brushy savannahs and on the cocoanut plantation proper, where small flocks were frequently noticed with the individual birds grouped closely together, usually all in the same bush. It was absent from the forested regions and upland savannahs.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22100	♂	Paracoté	50 Feet	February 5, 1932
22101	♂	Paracoté	50 Feet	February 7, 1923
22102	♂	Paracoté	50 Feet	February 7, 1932
22103	♀	Paracoté	50 Feet	February 7, 1932
22104	♀	Paracoté	50 Feet	February 7, 1932

Antrostomus carolinensis (Gmelin). CHUCK-WILL'S-WIDOW.

This North American migrant was flushed from the trail that runs along a forested ridge at 1500 feet elevation. The big goatsucker flew to a shrub near by where it perched and whence it was collected.

According to Griscom[59] there are only three records for the chuck-will's-widow in Panama, two from Chiriqui and one from Permé. The capture of this specimen is therefore of particular interest.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22105	♀	Altos Cacao	1500 Feet	March 17, 1932

Nyctidromus albicollis intercedens Griscom. CENTRAL AMERICAN PAURAQUE.

Compared with 3 specimens of *Nyctidromus albicollis intercedens* from Honduras our 5 Azuero Peninsula specimens of this goatsucker show some differences. In size they are apparently exactly

[59]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 317.

intermediate between *N. a. intercedens* and *N. a. albicollis*, and in this respect are similar to *Nyctidromus albicollis gilvus*. In color they are much closer to 3 Honduras specimens of *N. a. intercedens* than to 10 French Guiana specimens of *N. a. albicollis*. Although no specimens of *N. a. gilvus* were seen, it is judged from the description of that form that the Azuero Peninsula series is far too dark and heavily barred below, to be referable to it, being, if anything, darker and more heavily barred than are the Honduras birds.

At dusk the pauraques would start to limber up their voices, hesitating at first, but gradually gaining more smoothness and volume. Judging from the sounds they were common on the plantation. Individuals were often seen on the beach road during the short twilight, where they would sit on the open dusty areas, frequently jumping up into the air a few feet and then landing on the bare earth again. Presumably they were catching night flying insects which emerged from the brush that lined the road-sides.

The species was encountered twice in the forest away from the more open or brushy country of the plantation. Once a bird was flushed from the floor of the forest in daylight on the Mariato River, 10 miles from the coast. On another occasion a pair was found in the forest during the day at 1500 feet above sea level. This pair, from their behavior, which consisted of fluttering about close to me with trailing wings, gave the impression of attempting to lure me away from a nest or young birds. A search for these was fruitless, however. Judging from the frequency and intensity of the calls heard, the entire time of our stay fell within the breeding season of this species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22106	♂	Paracoté	Sea Level	February 9, 1932
22107	♂	Mariato River Camp	250 Feet	February 21, 1932
22108	♂	Altos Cacao	1500 Feet	March 2, 1932
22109	♀	Altos Cacao	1500 Feet	March 2, 1932
22110	♀	Paracoté	Sea Level	March 21, 1932

Chaetura vauxi ochropygia, subsp. nov. PALE-RUMPED SWIFT.

Subspecific Characters.—Similar to *Chaetura vauxi richmondi*, but averaging slightly smaller; rump and upper tail-coverts decidedly paler grayish brown, being much lighter than under parts instead of concolor as in *C. v. richmondi*. Similar also to *Chaetura vauxi gaumeri*, but with slightly paler rump and upper tail-coverts, and distinctly darker back, pileum, and under parts, and longer tail spines.

Measurements.—Adult male (2 specimens from the Azuero Peninsula): wing, 111.5-112 (average, 111.8) mm.; tail, 33-34.5 (33.8); exposed culmen, 5-5.5 (5.3); tarsus, 10-11.5 (10.8). Adult female (2 specimens from the Azuero Peninsula): wing, 109-112 (average, 110.5) mm.; tail, 34.5-37 (35.8); exposed culmen, 5; tarsus, 11.

Type.—Adult female, No. 22113, Cleveland Museum of Natural History; Paracoté, sea level, 1 mile south of the mouth of the Angulo River, east shore of Montijo Bay, Veraguas, Panama; February 15, 1932; John W. Aldrich, original number 1738.

Geographic Distribution.—Known from only the Azuero Peninsula, southern Veraguas, Panama. Probably intergrading with *Chaetura vauxi richmondi* in Chiriqui.

Remarks.—An excellent series of 34 specimens of *C. v. richmondi* from Mexico, Guatemala, Honduras, and Costa Rica, and 4 specimens of *C. v. gaumeri* from Yucatan were available for comparison, and the distinguishing characters of *C. v. ochropygia* mentioned above were found to be reasonably constant. The color of the rump and upper tail-coverts of each of the 4 specimens of *C. v. ochropygia* was found to be paler than any of the 34 specimens of *C. v. richmondi* which were rather uniform in respect to this character, although varying slightly geographically, the palest examples being from El General and Santa Maria de Dota, Costa Rica, and the darkest from Guatemala. A single topotypical specimen of *C. v. richmondi* from Guayabo, Costa Rica, is average for that race in respect to the color of the rump and upper tail-coverts. The color of the remainder of the upper parts and of the lower parts seems to be identical in *C. v. richmondi* and *C. v. ochropygia*. Compared to *C. v. gaumeri*,

C. v. ochropygia is distinctly darker throughout except on the rump and upper tail-coverts, where the latter averages even slightly paler, with this paleness extending farther anteriorly on the back. The tail spines of *C. v. ochropygia* are longer than those of *C. v. gaumeri*, but are of the same length as those of *C. v. richmondi*.

Although not having seen specimen showing complete intergradation, the writer follows Griscom[60] in considering *C. richmondi* and *C. gaumeri* as conspecific with *Chaetura vauxi*.

This interesting new race of the Vaux swift extends the range of that species about 160 miles farther toward South America, since it was previously known to occur only as far as western Chiriqui. The writer has not examined any specimens from that region and so cannot say to which race they belong, but would assume that they would be somewhat intermediate between *C. v. richmondi* and *C. v. ochropygia*.

The pale-rumped swift was rather a common bird both at sea level and at the higher altitudes, and at certain times it was much more in evidence than at others. Flocks were observed along the shore of Montijo Bay, over the horse pasture at Paracoté, over the clearing at Altos Cacao, and about the peak of Cerro Viejo. Toward the latter part of the afternoon was the most favorable time to see the largest concentrations of these swifts, and on a few occasions the air seemed to be fairly swarming with the birds.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22111	♂	Paracoté	Sea Level	February 15, 1932
22112	♀	Paracoté	Sea Level	February 15, 1932
22113	♀	Paracoté	Sea Level	February 15, 1932
22114	♂	Cerro Viejo, Cavulla	3000 Feet	February 15, 1932

Phaethornis superciliosa cephala (Bourcier and Mulsant). NICARAGUAN HERMIT.

Assuming that Griscom[61] is correct in referring the birds of this species from Costa Rica and western Panama to *Phaethornis superciliosa cephala* and those from eastern Panama to *Phaethornis superciliosa cassini*, the single specimen obtained on the Azuero Peninsula

[60]Bull. Amer. Mus. Nat. Hist., Vol. LXIV, May 7, 1932, p. 196.
[61]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 329.

should be referred to the former race. Although of slightly deeper buff below than the average of a series of 21 specimens from Costa Rica and Chiriqui, Panama, it is closer to these birds than to a series of 10 specimens from eastern Panama.

The Nicaraguan hermit was encountered in the forest on 3 occasions at as many different camps, and each time behaved in the same manner. I was, on all three occasions, unaware of its presence until it suddenly appeared before me on the trail, not more than 10 feet distant, motionless in the air except for rapidly vibrating wings and a nervous twitching of its long tail. The first 2 times this happened I tried to back away from the bird to obtain a safer distance for a shot, but on both occasions the curiosity of the bird was apparently satisfied before I could back far enough, and off it went as straight as an arrow through the forest. The third time I decided not to take a chance again and fired at point blank range with the result that the specimen is badly mutilated.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22148	♀	Paracoté	50 Feet	March 25, 1932

Campylopterus hemileucurus (Lichtenstein). DE LATTRE SABRE-WING.

After having examined a long series of this species from various parts of Central America including Chiriqui, the type locality of *Campylopterus hemileucurus mellitus* Bangs, together with our specimen from the Azuero Peninsula, the writer can see no reason for separating the birds of southern Central America from those of the northern part either on the basis of the characters described by Bangs[62] or any other character. The great variation in the amount of green on the males seems to be entirely due to age or individual variation. The writer therefore agrees with Ridgway[63] and Griscom[64] in recognizing but 1 form of this species.

Only 1 individual of this handsome hummingbird was seen, and that was in the forest at our highest camp on Cerro Viejo at an altitude of 3000 feet.

[62]Proc. New Eng. Zoöl. Club, Vol. III, January 30, 1902, p. 28.
[63]Bull. U. S. Nat. Mus., No. 50, Part V, November 29, 1911, p. 358.
[64]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 320.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22146	♂	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932

Florisuga mellivora mellivora (Linnaeus). JACOBIN HUMMINGBIRD.

The single specimen collected was the only one of this species encountered.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22147	♀	Paracoté	Sea Level	February 11, 1932

Bombornis cuvierii saturatior (Hartert). COIBA ISLAND HUMMINGBIRD.

Although I have been unable to obtain any topotypical specimens of *Bombornis cuvierii saturatior* from Coiba Island for comparison, I refer the above specimen to that form because its under parts are slightly darker than any of the 15 specimens studied of typical *Bombornis cuvierii cuvierii* from the Canal Zone. The measurements of our specimen, however, seem to fall within the range of those of Canal Zone birds. Our specimen does not show any of the characters which differentiate *Bombornis cuvierii maculicauda*, except a more greenish breast than that of typical *B. c. cuvierii*. This, however, is also characteristic of *B. c. saturatior*. My conviction that the Azuero Peninsula specimen should be referred to *B. c. saturatior* is strengthened by the view of Griscom[65] that the birds of the "heavy coastal forests of Veraguas" belong to that form, which was formerly supposed to be confined to Coiba Island.

The specimen collected was the only individual of this species observed.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22145	♀	Paracoté	Sea Level	March 23, 1932

[65]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 332.

Lepidopyga caeruleogularis caeruleogularis (Gould).
DUCHASSAIN HUMMINGBIRD.

The determination of the systematic status of our specimens of this form has not been wholly satisfactory because of my inability to obtain a single certainly typical specimen of *Lepidopyga caeruleogularis caeruleogularis* from Chiriqui for comparison. A single female from Costa Rica is more brassy on the back than any of the Azuero Peninsula specimens. Furthermore, compared with a series of 21 topotypical and nearly topotypical specimens of *Lepidopyga caeruleogularis confinis* from eastern Panama our specimens average almost as pure green on the back, in fact, some Obaldia specimens are more brassy on the back than ours. Comparing the color of the middle rectrices, those of the Azuero Peninsula specimens come well within the range of the series of *L. c. confinis* with respect to bronziness and purplish black tipping. In extent and intensity of the violet coloration of the throat, the Azuero Peninsula males are equal to or more extreme than the eastern Panama birds. In fact every character mentioned by Griscom[66] as important in separating *L. c. confinis* is found in equal intensity in a goodly number of the Azuero Peninsula birds. Not having seen any topotypical specimens of *L. c. caeruleogularis* I shall not hazard the suggestion that *L. c. confinis* is not recognizable; however, I can say with a reasonable amount of assurance that the characters upon which it is separated are subject to a great deal of individual variation and, if the form is recognizable, it is on the basis of rather finely drawn average characters. As for the status of our Azuero Peninsula specimens, I can only say that they average approximately the same in all of the characters I have discussed, as a series of 12 Canal Zone specimens which are generally considered to be referable to *L. c. caeruleogularis*.

This was the commonest species of hummingbird secured among those collected at random from the flowering trees on the plantation, and this probably represents its true status of comparative abundance in that region. It was a frequent visitor to the flowering bougainvillea bush in front of our house. Duchassain hummingbirds were not encountered away from the immediate vicinity of the cocoanut plantation.

[66]Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 333.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22121	♀	Paracoté	Sea Level	February 8, 1932
22122	♂	Paracote	Sea Level	February 11, 1932
22123	♂	Paracoté	Sea Level	February 13, 1932
22124	♀	Paracoté	Sea Level	February 17, 1932
22125	♂	Paracoté	Sea Level	February 21, 1932
22126	♂	Paracoté	Sea Level	February 21, 1932
22127	♂	Paracoté	Sea Level	February 21, 1932
22128	♀	Paracoté	Sea Level	February 21, 1932
22129	♂	Paracoté	Sea Level	February 22, 1923
22130	♀	Paracoté	Sea Level	February 23, 1932

Saucerottia niveoventer (Gould). SNOWY-BREASTED HUMMINGBIRD.

Specimens of *Saucerottia niveoventer* from Boquete, Panama, which are nearly topotypical, match ours very closely.

The 3 specimens taken at as many different camps and altitudes indicate that this species is fairly well distributed over the forested portion of the lower tropical zone of the Azuero Peninsula in spite of the fact that it is supposed to be found chiefly above 3000 feet in Chiriqui and Veraguas.[67]

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22136	♀	Paracoté	Sea Level	February 17, 1932
22137	♂	Mariato River Camp	250 Feet	February 23, 1932
22138	♂	Altos Cacao	1500 Feet	March 3, 1932

Amazilia tzacatl tzacatl (De La Llave). RIEFFER HUMMINGBIRD.

Except for possibly a slightly more grayish, less brownish abdomen, our specimens from the Azuero Peninsula do not differ from individuals from Mexico, and this character is subject to so much individual variation in both series that it is not considered of any subspecific importance with respect to the birds from the regions under question.

From the list of specimens collected at random it would seem that this is one of the commonest and most widely distributed hum-

[67]Griscom, Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 321.

mingbirds of the Azuero Peninsula having been taken at 3 stations from sea level to 3000 feet, both on the plantation and in the wilder sections.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22139	—	Altos Cacao	1500 Feet	March 5, 1932
22140	♂	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22141	♂	Paracoté	Sea Level	March 21, 1932
22142	♂	Paracoté	Sea Level	March 21, 1932
22143	♂	Paracoté	Sea Level	March 21, 1932
22144	♂	Paracoté	Sea Level	April 2, 1932

Hylocharis eliciae (Bourcier and Mulsant). ELICIA GOLDEN-TAIL.

The Elicia golden-tail is apparently fairly common and evenly distributed throughout the forested portions of the Azuero Peninsula, as well as about the clearings of the plantation. It was taken at two forest camps, one of them at an altitude of 250 feet, the other at 2000 feet. This was one of the commoner species observed at the Bougainvillea bush in front of our house on the plantation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22131	♀	Paracoté	Sea Level	February 10, 1932
22132	♂	Paracoté	Sea Level	February 17, 1932
22133	♂	Paracoté	Sea Level	March 23, 1932
22134	♀	Mariato River Camp	250 Feet	February 21, 1932
22135*	♂	Cerro Viejo Camp	2000 Feet	March 6, 1932

*Bill red with black tip.

Chlorostilbon assimilis Lawrence. ALLIED EMERALD.

No constant difference was detected between the Azuero Peninsula series and birds from the Canal Zone.

The allied emerald was one of the 4 commonest hummingbirds observed in the flowering trees and shrubs about the plantation. The 3 other rivals for abundance were the Duchassain and Rieffer hummingbirds and the Elicia golden-tail. Although no field census notes are available, the number of specimens collected more or less at random shows the allied emerald to be second only in numbers to the Duchassain hummingbird in the immediate vicinity of the

cocoanut plantation, where like the latter species, this little emerald seemed to be confined. The Rieffer hummingbird and Elicia goldentail, the only close rivals of the allied emerald for second place honors in abundance on the plantation were apparently more widely distributed throughout the wilder, forested areas as well.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22115	♀	Paracoté	Sea Level	February 9, 1932
22116	♀	Paracoté	Sea Level	Debruary 11, 1932
22117	♀	Paracoté	Sea Level	February 13, 1932
22118	♂	Paracoté	Sea Level	February 17, 1932
22119	♂	Paracoté	Sea Level	March 21, 1932
22120	♂	Paracoté	Sea Level	March 23, 1932

Klais guimeti (Bourcier and Mulsant). GUIMET HUMMINGBIRD.

All that can be said regarding the distribution of this species on the Azuero Peninsula is that our specimen, taken in a heavily forested area at an elevation of 2000 feet was the only one observed.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22149	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932

Trogon massena massena Gould. MASENA TROGON.

Two topotypical specimens of *Trogon massena massena* from Guatemala, which were available for comparison, were apparently radically altered in color by age, as the red of the posterior under parts was many shades paler, and the green of the breast, back, and head was much more brassy than was the case in our 2 specimens. For adequate systematic work on this species it would evidently be more than ordinarily desirable to use specimens for comparison which were collected at approximately the same time.

Attention is called to the field note on the color of the naked eyelid in our specimens, which was red rather than "sky blue" as given by Ridgway[68] for this species.

Only 3 individuals of this brilliantly colored trogon were seen on the entire trip. Two of these were found on the plantation in

[68]Bull. U. S. Nat. Mus., No. 50, Part V, November 29, 1911, p. 744.

small patches of forest and the other was at the edge of a dense thicket in the clearing at Altos Cacao. In each case the bird was rather quiet and sluggish in its behavior.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22150*	♂	Paracoté	Sea Level	February 10, 1932
22151	♂	Altos Cacao	1500 Feet	March 3, 1932

*Eyelids red. Iris light brown.

Megaceryle torquata torquata (Linnaeus). RINGED KINGFISHER.

A pair of these big kingfishers made its headquarters on the Mariato River near our camp, but all attempts to collect the birds failed.

Chloroceryle americana isthmica (Goldman). ISTHMIAN GREEN KINGFISHER.

This little kingfisher was seen rather frequently along the road through the mangrove swamp and at the edge of the mangroves along the estero at Paracoté, also occasionally along the Mariato River at our camp on that stream.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22158	♀	Mariato River Camp	250 Feet	February 21, 1932
22159	♂	Paracoté	Sea Level	March 27, 1932
22160	♀	Paracoté	Sea Level	March 27, 1932
22161	♂	Paracoté	Sea Level	March 29, 1932
22162	♂	Paracoté	Sea Level	March 29, 1932
22163	♀	Paracoté	Sea Level	March 29, 1932
22164	♂	Paracoté	Sea Level	March 30, 1932

Chloroceryle aenea aenea (Pallas). LEAST GREEN KINGFISHER.

The single specimen collected was taken in the mangrove fringe of the estero at Paracoté. It was the only individual of this species observed.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22165	♂	Paracoté	Sea Level	March 30, 1932

Momotus momota lessonii Lesson. LESSON MOTMOT.

An examination of 55 specimens of *Momotus momota lessonii* from various parts of its range shows very clearly the existence of two color phases, as noted by Griscom,[69] a rufous phase and a bluish green phase, in which respectively these two colors predominate. There is, however, every stage of intergradation between the two, and they seem to be independent of sex, age and geographic distribution.

It is the writer's opinion that *Momotus lessonii* and its subspecies are geographic races of *Momotus momota*, as suggested by Peters.[70] Intergradation through individual variation was found to exist between our Azuero Peninsula series of *lessonii* and examples of the *momota* group from the Amazon valley. No indication was found, however, of intergradation with *Momotus subrufescens connexus* from the Canal Zone.

Although *Momotus momota lessonii* has been repeatedly characterized as a Subtropical Zone form, particularly in the southern part of its range, the writer's observations on the Azuero Peninsula, which is, so far as known, the extreme southernmost extension of the range of this form, tend to show that, there at least, this bird is rather common in the lower tropical forests even down to sea level. This fact would tend to invalidate Chapman's[71] theory that the apparent absence of a representative of the *Momotus lessonii* group between the subtropical zone of western Panama and the same zone of north-western Colombia is due to the subsidence of a subtropical zone bridge which once connected these two regions. Since the Lesson motmot seems to be perfectly at home in the Tropical Zone forests, at least in some parts of the range, the lowland forests of the Isthmus of Panama would hardly be a barrier to the bird's dispersal.

Chapman,[72] without indicating the fact by nomenclature, stated that "*Momotus aequatorialis* is clearly the representative in the Andean Subtropical Zone of the Middle American *Momotus lessonii*." Austin[73] stated definitely that "*aequatorialis* of Colombia is a race of *lessoni*, but the strange thing is its apparent affinity for the southern Mexican bird rather than its nearest neighbor in

[69]Bull. Amer. Mus. Nat. Hist., Vol. LXIV, May 7, 1932, p. 182.
[70]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 12, October, 1929, p. 425.
[71]Bull. Amer. Mus. Nat. Hist., Vol. XLVIII, 1923, pp. 51-52.
[72]Bull. Amer. Mus. Nat. Hist., Vol. XLVIII, 1923, p. 34.
[73]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 11, September, 1929, p. 375.

Panama." On the basis of these findings it would seem that all the forms of the *lessonii* and *aequatorialis* groups should be considered as subspecies of *Momotus momota*, but the members of the *subrufescens* group should be maintained as a distinct species.

The Lesson motmot was a fairly common species in the forest at Paracote and the Mariato River camp. As we ascended the mountains it seemed to be less common and above 1500 feet was not even recorded.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22152	♀	Paracoté	Sea Level	February 7, 1932
22153*	♂	Mariato River Camp	250 Feet	February 23, 1932
22154	♀	Mariato River Camp	250 Feet	February 23, 1932
22155*	♀	Altos Cacao	1500 Feet	March 5, 1932
22156	♂	Paracoté	Sea Level	March 19, 1932
22157	♀	Paracoté	Sea Level	March 19, 1932

*Iris red.

Notharchus hyperrhynchus dysoni (Sclater). DYSON PUFFBIRD.

Our specimens of this species are not different from Honduras examples and so belong to the race *Notharchus hyperrhynchus dysoni* rather than to *N. h. hyperrhynchus*, which according to Griscom[74] extends into Panama from South America as far as the Canal Zone.

One specimen was collected from its perch on an exposed dead branch of a large tree overlooking the mangrove-covered edge of the estero at Paracoté. The other was taken from a similar perch in a large tree on the precipitous ridge at Altos Cacao. In both cases the birds sat as motionless as statues while being approached sufficiently close for a shot.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22170	♀	Paracoté	Sea Level	February 17, 1932
22171*	♀	Altos Cacao	1500 Feet	March 1, 1932

*Iris red.

[74]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 328.

Malacoptila panamensis panamensis Lafresnaye. PANAMA MALACOPTILA.

This sluggish species was apparently fairly common in the forested regions visited. When encountered it was always sitting quietly on some low branch, usually not more than 6 to 10 feet above the ground. It could be approached rather closely before taking wing, when it would fly for a few yards only and take up another perch always at approximately the same height above the ground.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22172	♂	Mariato River Camp	250 Feet	February 21, 1932
22173*	♀	Mariato River Camp	250 Feet	February 24, 1932
22174*	♀	Mariato River Camp	250 Feet	February 26, 1932
22175	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932
22176	♀	Cerro Viejo Camp	2000 Feet	March 9, 1932
22177	♀	Paracoté	Sea Level	March 29, 1932
22178	♂	Paracoté	Sea Level	April 1, 1932

*Iris red.

Rhamphastos sulphuratus brevicarinatus Gould. SHORT-KEELED TOUCAN.

The specimens that we obtained are indistinguishable from an eastern Panama (Port Obaldia) example.

The short-keeled toucan, called "joralico" and "pico feo" by the natives, was a rather common species in the forested areas at all altitudes visited. At Cavulla, altitude 3000 feet, one was seen to leave a tongue of forest and fly, with its curious looping flight, to another about a quarter of a mile across a grassy llano.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22166*	♂	Paracoté	Sea Level	February 10, 1932
22167	♀	Paracoté	Sea Level	February 11, 1932
22168	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932
22169	♀	Paracoté	Sea Level	March 19, 1932

*Feet light blue. Iris and skin around eye greenish yellow. Bare skin behind eye yellow.

Centurus rubricapillus wagleri (Salvin and Godman). WAGLER WOODPECKER.

As Todd and Carriker[75] have pointed out, there is considerable individual as well as seasonal color variation in this species. These authors have mentioned the fact that Costa Rica examples seem to show a restriction of the red color of the abdomen and more white on the lateral rectrices, but they have not recognized these differences in nomenclature. However, with a series of 59 specimens of this species at hand including 3 topotypes of *Centurus rubricapillus wagleri*, and representing localities in the Pearl Islands, Canal Zone, Veraguas, Chiriqui, and southwestern Costa Rica, it is apparent, after separating the birds into groups according to season and sex, that there is a very definite difference in size and color between groups from Costa Rica and seasonally as well as sexually comparable groups from the Canal Zone (typical *wagleri*). Todd and Carriker[75] have noted part of the color difference, and Ridgway,[76] without commenting, showed, in his table of measurements, the smaller size of Costa Rica birds.

In the series now examined, 14 birds from Costa Rica average distinctly of a paler and more olive, less ochraceous gray below; have the red of the abdomen more restricted; and average smaller, particularly in the wing, than specimens of typical *C. r. wagleri* from the Canal Zone. I am, however, unable to verify the character of more white in the lateral rectrices mentioned by Todd and Carriker. The Azuero Peninsula specimens, although they are slightly paler and more yellowish below, particularly about the border of the red abdominal patch, than Canal Zone birds, do not seem to be different enough to warrant separation. Oddly enough birds from Chiriqui, which region is geographically intermediate between the Azuero Peninsula and Costa Rica, are as dark and as ochraceous below as Canal Zone birds, and one specimen from Boquete comes very close in color of under parts to Pearl Islands birds, (*Centurus rubricapillus seductus*). It seems very strange that Chiriqui examples should differ so markedly from those from western Costa Rica since the two regions are in general faunally alike. Nevertheless, it appears that a sufficient series is at hand to show this to be the case, and on the

[75]Ann. Carnegie Mus., Vol. XIV, October, 1922, p. 240.
[76]Bull. U. S. Nat. Mus. No. 50, Part VI, April 8, 1914, p. 74.

basis of the facts presented, the Costa Rica bird should be considered a distinct subspecies which I propose to call:

Centurus rubricapillus costaricensis, subsp. nov.Costa Rica Woodpecker.

Subspecific Characters.—Similar to *Centurus rubricapillus wagleri* from the Canal Zone, Veraguas, and Chiriqui, Panama, but smaller; under parts paler and of a more olive, less ochraceous gray; red abdominal patch more restricted.

Measurements.—*Adult male* (11 specimens from southwestern Costa Rica): wing, 105-113. (average, 109.7) mm.; exposed culmen, 21-24 (22.1); tail, 51-55 (52.4); tarsus, 18.5-19 (18.9). *Adult female* (4 specimens from southwestern Costa Rica): wing, 104.5-113 (average, 107.5) mm.; tail, 52.5; exposed culmen, 18-21 (19.5); tarsus, 17.5.

Type.—Adult male, No. 22572, Cleveland Museum of Natural History; El Pozo, altitude 25 feet, Rio Terraba, Puntarenas, Costa Rica; May 13, 1930; Austin Smith, original number 8577; "tarsi olive, irids dark brown."

Geographic Distribution.—As far as known, confined to southwestern Costa Rica. Specimens have been seen from El Pozo, Boruca, Puerto Uvita, and Buenos Aires, Costa Rica.

The wagler woodpecker (*Centurus rubricapillus wagleri*) was very common in the more open country at Paracoté. A pair insisted on digging a nesting cavity in the flag-pole at the plantation headquarters despite all attempts to discourage them, until they were added to the collection. The species was absent from the more heavily forested regions, but a single specimen was taken from second-growth jungle on the site of an old abandoned rubber operations headquarters near our Mariato River camp.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22182	♀	Paracoté	Sea Level	February 9, 1932
22183	♂	Paracoté	Sea Level	February 12, 1932
22184	♂	Paracoté	Sea Level	February 14, 1932
22185	♂	Paracoté	50 Feet	February 14, 1932
22186	♀	Paracoté	50 Feet	February 14, 1932
22187	♀	Mariato River Camp	250 Feet	February 26, 1932

Phloeoceastes melanoleucus malherbii (Gray). MALHERBE WOODPECKER.

The specimen collected is not distinguishable from Canal Zone and eastern Panama examples.

Two of these big woodpeckers were seen together in a large tree at the edge of the forest at Paracoté. From the courtship behavior it was apparent that this was a mated pair. The female was collected, and neither the mate, which escaped, nor any other bird of this species was ever seen again during our trip.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22181	♀	Paracoté	Sea Level	February 17, 1932

Ceophloeus lineatus mesorhynchus Cabanis and Heine. PANAMA PILEATED WOODPECKER.

Compared with a series of 16 specimens of *C. l. mesorhynchus* from western Panama and Costa Rica, ours are slightly more buffy on the light-colored areas. One of the 2 individuals from the Azuero Peninsula is much more extensively black on the under parts, particularly in respect to the size of the spots on the abdomen, than any other bird in the series. Since, however, the other of our specimens is not more blackish than the average of the series and differs only in being more buffy, it is probably better to refer the Azuero birds to *P. l. mesorhynchus* until such time as a larger series from that region is available to show whether or not the above-mentioned characters are constant.

The 2 specimens collected are from the same general region in the forested bottomlands at Paracoté. The bird obtained on March 24 was busy excavating a nesting cavity when collected.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22179*	♀	Paracoté	Sea Level	February 6, 1932
22180	♀	Paracoté	Sea Level	March 24, 1932

*Ovary well developed.

Xiphorhynchus guttatus marginatus Griscom. GRISCOM WOODHEWER.

Our series bears out very well the distinctive characters used by Griscom[77] to differentiate this race from *Xiphorhynchus guttatus costaricensis*, particularly the darker chestnut of the wings, the darker sooty tips of the primaries, and the brighter buff of the throat. A character not mentioned as diagnostic in the original description, which is shown clearly in our specimens, is the more blackish edging of the crown and nape feathers. This is a feature which seems to present more of a contrast to the condition found in *X. g. costaricensis* than do the markings of the under parts. The latter character, however, is noticable on close scrutiny.

This woodhewer was a common bird both in the deeper forests of the interior of the Azuero Peninsula and in the second growth jungle in the vicinity of the plantation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22223	♂	Paracoté	Sea Level	February 10, 1932
22224	♀	Mariato River Camp	250 Feet	February 22, 1932
22225	♀	Mariato River Camp	250 Feet	February 23, 1932
22226	♂	Altos CaCao	1500 Feet	March 1, 1932
22227	♀	Altos CaCao	1500 Feet	March 6, 1932
22228	♀	Cerro Viejo Camp	2000 Feet	March 9, 1932
22229	♀	Paracoté	50 Feet	March 22, 1932
22230	♂	Paracoté	Sea Level	March 25, 1932
22231	♀	Paracoté	Sea Level	March 28, 1932

There are in the American Museum of Natural History 1 male and 5 female specimens collected by Rex Benson[78] on the Cape Mala [= Azuero] Peninsula.

Sittasomus griseicapillus veraguensis, subsp. nov. VERAGAUS WOOD-CREEPER.

Subspecific Characters—Similar to *Sittasomus griseicapillus levis* but smaller; more greenish olive gray on the head, neck and under parts; slightly more tawny on posterior abdominal region.

Measurements.—Adult male (1 specimen from the Azuero Peninsula); wing, 78 mm.; tail, 73.5; exposed culmen, 13.5; tarsus, 17.5. *Adult female* (3 specimens from the Azuero Peninsula): wing, 68-73 (aver-

[77]Amer. Mus. Novit., No. 280, September 10, 1927, pp. 7-8.
[78]Griscom, Amer. Mus. Novit., No. 280, September 10, 1927, p. 7.

age, 70) mm.; tail, 51-70.5 (61.7); exposed culmen, 13.5-14.5 (14); tarsus, 17-18 (17.5).

Type.—Adult male, No. 22232, Cleveland Museum of Natural History; Mariato River, elevation 250 feet, 10 miles east of Montijo Bay, Veraguas, Panama; February 24, 1932; John W. Aldrich, original number, 1821.

Geographic Distribution.—Forested areas of the Pacific slopes of the main cordillera of Veraguas and the Azuero Peninsula.

Remarks.—The birds from the Azuero Peninsula are distincly different from a topotypical series of 11 specimens of *Sittasomus griseicapillus levis* from Boquete, particularly in the more greenish cast of the olive gray of the head, neck, and under surface. Four individuals examined from Chitra on the Pacific slope of the main Cordillera of Veraguas in the collection of the American Museum of Natural History are apparently referable to *S. g. veraguensis* also, being, like the Azuero Peninsula specimens, more greenish than the Boquete series of *S. g. levis*. They are, however, intermediate in size, and somewhat darker below than typical *S. g. veraguensis*. A single male from Cascajal, Coclé, is distinctly different in color from either Boquete, Azuero Peninsula, or Chitra birds, being more brownish below with a more pronounced rufescent wash on the abdomen, and a richer, more rufescent brown back. If these characters were found to hold in series, this would be a very distinct geographic race, and in this event it would be necessary to recognize 3 different subspecies of *Sittasomus griseicapillus* on the Pacific slope of Panama west of the Canal Zone. Two specimens from Cana in eastern Panama do not seem to present any noticeable color differences from Boquete examples of *S. g. levis*, although one of the birds, a female, is even smaller than the average of *S. g. veraguensis* from the Azuero Peninsula. If these Cana specimens were to be referred to *S. g. levis*, this form would present a discontinuous range with the western part separated from the eastern by the range of *S. g. veraguensis*. No examples of *Sittasomus griseicapillus griseus* of the Caribbean coast of Venesuela have been seen so it cannot be said what relation the eastern Panama bird may bear to that form.

It is obvious that we are here dealing with one of the morphologically most plastic of neotropical birds, which is separable into a great many local geographic races. The feasibility of recognizing all of these in nomenclature is of course open to question. However, in the above described form, *S. g. veraguensis*. it seems to me that the difference between the Azuero Peninsula and Boquete birds is pronounced enough and constant enough to warrant considering the birds from the 2 regions as belonging to separate subspecies.

The Veraguas wood-creeper was not a common species but was fairly evenly distributed throughout the more heavily forested area visited from at least 250 feet to 3000 feet above sea level.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22232	♂	Mariato River Camp	250 Feet	February 24, 1932
22233	♀	Altos Cacao	1500 Feet	February 28, 1932
22234	♀	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22235	♀	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932

Xenops minutus ridgwayi Hartert and Goodson. RIDGEWAY XENOPS.

The writer follows Griscom[79] in referring our specimens to *Xenops minutus ridgwayi*. Two individuals from the Azuero Peninsula are almost indistinguishable from 2 others from Divala, western Panama, which should be typical *X. m. ridgwayi*, but the other 2 Azuero birds are closer in color to 2 from El Tigre and Permé, eastern Panama, which Griscom[79] referred to *X. m. littoralis*. However, as no typical Ecuador specimens of the latter form are at hand for comparison it seems better to refer our specimens to *X. m. ridgwayi*, from which the difference is, at best, extremely slight, and can probably be best explained as a tendency toward intergradation with *X. m. littoralis*, a condition found by Zimmer[80] to exist also among Canal Zone specimens.

Three of the specimens were taken from a single flock of these birds which was encountered in the deep forest on the banks of the Mariato River. The birds were flitting about in the manner of some of the North American warblers, high up in the trees. The fourth specimen was found alone in the forest at Paracoté.

[79]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 8, April 29, 1929, p. 171.
[80]Amer. Mus. Novit., No. 862, June 23, 1936, pp. 23-25.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22219	♂	Mariato River Camp	250 Feet	February 24, 1932
22220	♀	Mariato River Camp	250 Feet	February 24, 1932
22221	♀	Mariato River Camp	250 Feet	February 24, 1932
22222	♂	Paracoté	50 Feet	April 1, 1932

Thamnophilus doliatus nigricristatus Lawrence. BLACK-CRESTED ANTSHRIKE.

The male specimens obtained on the Azuero Peninsula differ from a single topotypical specimen of *Thamnophilus doliatus nigricristatus* from Lion Hill, Panama, in having no white in the center of the crown when the feathers are parted and in being more extensively black, having broader black bars on the bersat and smaller white spots on the back, in the last character resembling an example of *T. d. intermedius* from Costa Rica and one from Honduras. Our Azuero Peninsula female is of a darker rufous on the back than a Canal Zone specimen of *T. d. nigricristatus*, but slightly paler than the females of *T. d. intermedius*. These characteristics of the Azuero Peninsula bird, although possibly showing some intergradation between *T. d. nigricristatus* and *T. d. intermedius* in body color, are for the most part an intensification of the characters that separate *T. d. nigricristatus* from *T. d. albicans* of Colombia, while the unbroken black crown separates the former race very distinctly from *T. d. intermedius* of Costa Rica and northward. These findings further substantiate the statement of Cory and Hellmayr[81] that "the black-crested antshrike is the only form occuring in Veragua."

This species was rather common in the more open brushy country about the plantation and even in the shrubbery about the houses. It was the only member of the family found away from the forest, in fact it was confined to open shrubby country. Only a single specimen was found away from the plantation proper, and that was taken in the small area of formerly cultivated land at Altos Cacao, altitude 1500 feet, which, not having been planted for a few years, had grown up to a dense tangle of sprouts and vines.

[81]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part III, November 20, 1924, p. 71.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22188	♂	Paracoté	50 Feet	February 5, 1932
22189	♂	Paracoté	50 Feet	February 12, 1932
22190	♂	Paracoté	50 Feet	February 12, 1932
22191	♂	Paracoté	50 Feet	February 18, 1932
22192	♂	Paracoté	50 Feet	March 21, 1932
22193	♂	Paracoté	50 Feet	March 21, 1932
22194*	♀	Altos CaCao	1500 Feet	March 2, 1932

*Feet bluish gray. Iris white.

Thamnophilus bridgesi Sclater. BRIDGES ANTSHRIKE.

The only detectable color difference between our Azuero Peninsula specimens and a large series from Costa Rica and extreme western Panama (Divala) was a slightly more whitish appearance of the top of the head of the Azuero females due to the broader white streaks of the crown. However, since this character is subject to some individual variation, and the difference slight at best, it does not seem desirable to attempt the separation of the Azuero Peninsula birds on the basis of that alone.

This was one of the commonest birds of the forest, where it kept to the low dense undergrowth, being frequently seen flitting about close to the ground. The species seemed to be comparatively unwary. On one occasion I found myself within 6 feet of a male which sat calmly watching me from a shrub at the edge of our camp clearing on the Mariato River.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22195	♂	Paracoté	50 Feet	February 9, 1932
22196	♀	Paracoté	50 Feet	February 9, 1932
22197	♂	Mariato River Camp	250 Feet	February 24, 1932
22198	♂	Altos Cacao	1500 Feet	March 3, 1932
22199	♂	Mariato River Camp	250 Feet	March 17, 1932
22200	♀	Paracoté	50 Feet	March 25, 1932
22201	♀	Paracoté	50 Feet	March 25, 1932
22202	♂	Paracoté	50 Feet	March 29, 1932
22203	♀	Paracoté	50 Feet	March 29, 1932

Myrmotherula fulviventris Lawrence. LAWRENCE ANTWREN.

The 2 immature males of this species collected, although still olive tawny on the breast are beginning to acquire on the throat the black

coloration of the adult male plumage. These 2 specimens, taken in the forest at two different localities, represent all of the knowledge we possess concerning the distribution of this humid tropical zone species on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22204	♂ im.	Mariato River Camp	250 Feet	February 24, 1932
22205	♂ im.	Cerro Viejo Camp	2000 Feet	March 6, 1932

Cercomacra tyrannina rufiventris (Lawrence). WESTERN TYRANNINE ANTBIRD.

There is considerable discussion in ornithological literature concerning the distribution of the various forms of *Cercomacra tyrannina* in southern Central America. Bangs, in 1901[82], initiated the discussion when he described *Cercomacra tyrannina crepera* from Divala, Chiriqui, as distinct from *C. t. tyrannina* on the basis of its much darker coloration throughout in both sexes. Carriker, in 1908[83], called attention to the fact that, although the specimens of the Caribbean coast of Costa Rica fit the description of *C.t.crepera*, those from the southwestern part of that country are paler and agree with the description of the type of *C. t. tyrannina*. He came to the conclusion that *C. t. crepera* is confined almost entirely to the Caribbean slope of Costa Rica and western Panama, but extends over the divide in western Chiriqui to Divala (the type locality) on the Pacific coast. Thus it interrupts at that point the range of *C. t. tyrannina* which extends otherwise unbroken from Colombia along the Pacific slope of Panama to southwestern Costa Rica. Ridgway in 1911[84], was evidently somewhat confused by the apparent individual variation of the Central American examples of this race, but recognized two forms in Panama, *C. t. tyrannina* from Cascajal, Coclé, eastward, and *C. t. crepera* from Santa Fé de Veragua westward. Hellmayr, in 1911[85], drew the line of separation between the dark and light forms in a different place. He considered that birds from Guatemala, Costa Rica, Chiriqui, western Colombia, and northwestern Equador are "not withstanding some individual variation" much darker than specimens from Bogota (topotypes of *tyrannina*), the upper Orinoco, British Guiana, and northern Brazil. In view of this similarity be-

[82]The Auk, Vol. XVIII, No. 4, October, 1901, pp. 365-366.
[83]Ann. Carnegie Mus., Vol. VI, Nos. 2, 3, and 4, August, 1910, p. 613.
[84]Bull. U. S. Nat. Mus., No. 50, Part V, November 29, 1911, pp. 93-97.
[85]Proc. Zoöl. Soc. London, 1911, Part IV, December 15, 1911, pp. 1165-1166.

tween all the birds of southern Central America, Hellmayr considered that Lawrence's name *Disythamnus rufiventris*[86], based on a bird from Lion Hill, Panama, must take precedence over *C. t. crepera*. Chapman, in 1917[87], although noting in central and eastern Panama, southwestern Colombia, and western Ecuador, specimens of darker coloration than true *C. t. tyrannina*, considered them nearer to that race than to *C. t. crepera*. Cory and Hellmayr, in 1924[88], recognized *C. t. rufiventris* as distinct from both *C. t. tyrannina* and *C. t. crepera*, and as occupying a range extending from the Isthmus of Panama through western Colombia south to Chimbo, western Ecuador. Griscom, in 1935[89], apparently agrees with these views, as he refers all Panama birds from the Canal Zone eastward, to *C. t. rufiventris*, and those of the western half of that country to *C. t. crepera*.

With these views the writer also heartily agrees, except that he would extend the range of *C. t. rufiventris* westward along the Pacific slope to include Coclé, whence came the specimen referred to *C. t. tyrannina* by Ridgway, and the Azuero Peninsula. The 2 specimens obtained by us in the latter region are apparently typical *C. t. rufiventris*, as they are indistinguishable from specimens from Cana, eastern Panama, and nothing like examples of *C. t. crepera* from Almiranti, Bocas del Toro, and Chiriqui, Panama; and from Boruca, southwestern Costa Rica, being much paler both in the male and the female. It is interesting to note that specimens from Santa Fé, Veraguas, were refered to *C. t. crepera* by Ridgway, which indicates that this form may range farther east in the mountain forests north of the Azuero Peninsula.

Nothing further than the record of the 2 specimens captured at 2 different forest localities can be offered by way of information concerning the abundance and distribution of the western tyrannine antbird on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22206	♂	Mariato River Camp	250 Feet	February 21, 1932
22207	♀	Altos Cacao	1500 Feet	March 5, 1932

[86]Lawrence, Ann. Lyc. Nat. Hist. N. Y., Vol. VIII, 1867, p. 131.
[87]Bull. Amer. Mus. Nat. Hist., Vol. XXXVI, 1917, p. 380.
[88]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part 3, November 20, 1924, pp. 216-217.
[89]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 335.

Myrmeciza exul occidentalis Cherrie. CHERRIE ANTBIRD.

The specimens collected agree perfectly with a series of typical *Myrmeciza exul occidentalis* from southwestern Costa Rica.

This species rivaled the Bridges antishrike as the most abundant formicarian species in the forest regions of the Azuero Peninsula, and like that form was characteristic of the dense undergrowth, keeping near the floor of the forest.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22208*	♂	Paracoté	Sea Level	February 6, 1932
22209†	♂	Paracoté	Sea Level	February 9, 1932
22210†	♀	Paracoté	Sea Level	February 9, 1932
22211†	♂	Mariato River Camp	250 Feet	February 21, 1932
22212†	♀	Altos CaCao	1500 Feet	February 28, 1932
22213	♂	Cerro Viejo Camp	2000 Feet	March 8, 1932
22214	♂	Cerro Viejo Camp	2000 Feet	March 9, 1932
22215	♂	Paracoté	Sea Level	April 1, 1932

*Skin of head bright blue.
†Skin around eye blue.

Attila spadiceus citreopygus (Bonaparte). CITRON-RUMPED ATTILA.

The single specimen obtained is very similar to specimens of *Attila spadiceus citreopygus* examined from extreme western Panama and is therefore appreciably different from examples of *Attila spadiceus sclateri* from eastern Panama.

The individual collected was obtained in the heavy forest along the river at Mariato River camp and was the only one of the species seen on the entire trip.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22239	♂	Mariato River Camp	250 Feet	February 23, 1932

Pachyrhamphus polychropterus cinereiventris Sclater. GRAY-BELLIED BECARD.

An insufficient series has been seen to warrant any opinion as to the status of the geographic variation of this form in southern

Central America. Recent opinions seem to concur in considering *Pachyrhamphus polychropterus tantalus* [= *costaricensis*] as unrecognizable. Hellmayr[90] considers the birds of southern Central America from Guatemala to the Canal Zone as referable to *Pachyrhamphus polychropterus similis* and confines *Pachyrhamphus polychropterus cinereiventris* to northern Colombia and extreme eastern Panama. Griscom[91] refers all birds from Guatemala to Colombia to *P. p. cinereiventris*. Our specimens do vary distinctly from supposedly typical specimens of *P. p. similis* from Nicaragua in being of a distinctly paler gray below and less extensively black on the back, also in the female, more brightly and more extensively yellow below. Not having seen any typical specimens of *P. p. cinereiventris*, I cannot say how our specimens vary, if they do, from that form. According to Ridgway's diagnosis,[92] our specimens come closer to *P. p. cinereiventris* than to *P. p. similis*. Bangs and Penard[93] say that the species attains the palest coloration in Costa Rica in which region they recognized a distinct form *P. p. costaricensis*. Our specimens apparently tend to bear out the validity of a different race in western Panama and western Costa Rica, but a much larger series from that region as well as from the ranges of *P. p. similis* and *P. p. cinereiventris* than I have seen is needed before definitely stating this to be the case. Until the writer has had such opportunity he is inclined to follow Griscom[94] in uniting all the birds from these regions under the oldest name available, which is *P. p. cinereiventris*.

The gray-bellied becard was evidently rather evenly distributed although not very common throughout the forested areas visited, since a specimen was taken at each of the 3 camps at varying altitudes of from 50 to 1500 feet.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22240	♂im.	Mariato River Camp	250 Feet	February 23, 1932
22241	♀	Altos CaCao	1500 Feet	February 28, 1932
22242	♂	Paracoté	50 Feet	April 1, 1923

[90]Zool. Ser., Field Mus. Nat. Hist., Vol. XIII, November 14, 1929, pp. 184-185.
[91]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 345.
[92]Bull. U. S. Nat. Mus., No. 50, Part IV, July 1, 1907, pp. 829-832.
[93]Bull. Mus. Comp. Zoöl., Vol. LXIV, No 4, January, 1921, p. 383.
[94]Bull Mus Comp Zoöl, Vol LXXVIII, No 3, April, 1935, p 345

Tityra semifasciata costaricensis Ridgway. COSTA RICAN TITYRA.

A pair of these birds had evidently become established for the purpose of nesting near our camp at Altos Cacao. The male of this pair was collected on February 28. On March 1 another male appeared and proceeded to attempt to win the female, which had remained in the vicinity. At intervals the male pursued the female in a large circle around and around among the trees surrounding our camp clearing. After several circuits had been made the birds would stop and rest and then resume the performance. This was continued for several hours until this second male was collected. The following day another male appeared on the scene and took up the circular chase where it had been left off by his predecessor the day before. This time the new male was not molested, but left to carry on the nesting activities with the female. The pair was seen together just before we left that camp on March 6.

Only one other Costa Rican tityra was seen. That was the one collected at Paracoté while it was feeding on small berry-like fruit in a large tree at the edge of the forest.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22237	♂	Paracoté	Sea Level	February 8, 1932
22236	♂	Altos Cacao	1500 Feet	February 28, 1932
22238	♂	Altos Cacao	1500 Feet	March 1, 1932

Pipra mentalis ignifera Bangs. SOUTHERN YELLOW-THIGHED MANAKIN.

Our series of this species more nearly resembles specimens of *Pipra mentalis ignifera* from Divala than examples of *Pipra mentalis minor* from the Canal Zone and Colombia.

Yellow-thighed manakins were found only in the bottomland forests at or near sea level at Paracoté where they were fairly common. One of the specimens collected had a bot fly larva embedded under the skin at the corner of the mouth. This was the only case

of infestation of birds by this group of parasites which were so commonly found in mammals, particularly the howler monkey *Alouatta* and which even found the writer to its liking.

Specimens Collected

C. M. N. H. Number	Sex	Locality	Elevation	Date
22270	♂	Paracoté	Sea Level	February 6, 1932
22271	♂	Paracoté	Sea Level	February 6, 1932
22272*	♂	Paracoté	Sea Level	February 9, 1932
22273	♂	Paracoté	Sea Level	March 24, 1932
22274*	♂	Paracoté	Sea Level	March 25, 1923
22275	♂	Paracoté	Sea Level	March 25, 1932
22276	♂	Paracoté	Sea Level	April 1, 1932
22277	♂	Paracoté	Sea Level	April 1, 1932

*Iris white.

Chiroxiphia lanceolata (Wagler). SHARP-TAILED MANAKIN.

In all, 44 specimens of this species from localities ranging from Chiriqui to Venezuela have been examined. The only variation in any way correlated with geographic distribution noted in this series is a tendency toward duller, less blackish and more greenish under parts of the males from Margarita Island, Venezuela, and slightly purer, less yellowish green upper parts of the females from western Panama (Azuero Peninsula and Boquete). The former difference in the birds from Venezuela has been noted by Hellmayr,[95] and the latter by Miller[96] in females from Coiba Island, western Panama. These variations, however, seem too slight and individually variable to warrant subspecific separation at the present time.

The sharp-tailed manakin was the commonest bird in the forests at all elevations, at least up to 2000 feet. Its pleasing bell-like call remains in my mind as the most characteristic sound of the Azuero Peninsula forests. One could not walk far through the woods without encountering at least one of these interesting little birds, and on several occasions we witnessed the curious dance of this species. Two males would fly from their perches and meet in mid-air, whereupon they would proceed to move up and down in the air in rythmic alternation as if suspended, like puppets, by concealed threads. These manoeuvers were accompanied by curious scraping sounds the source of which was undetermined. After a few seconds the

[95]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part VI, November 14, 1929, p. 54.
[96]Bull. Amer. Mus. Nat. Hist., Vol XXIV, 1908, p. 335.

two birds would resume their perches, and possibly, after a short rest, repeat the performance. The clear bell-like "tow, tow" call was given only when the bird was at rest, and apparently was not connected with the dance.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22250*	♂	Paracoté	Sea Level	February 6, 1932
22251*	♂ im.	Paracoté	Sea Level	February 6, 1932
22252*	♂	Paracoté	50 Feet	February 9, 1932
22253	♂	Paracoté	50 Feet	February 14, 1932
22254	♂	Paracoté	Sea Level	February 14, 1932
22255	♀	Paracoté	Sea Level	February 17, 1932
22256	♀	Mariato River Camp	250 Feet	February 22, 1932
22257	♂	Mariato River Camp	250 Feet	February 23, 1932
22258	♂ im.	Altos Cacao	1500 Feet	March 3, 1932
22259	♂	Altos Cacao	1500 Feet	March 4, 1932
22260	♀	Cerro Viejo Camp	2000 Feet	March 6, 1932
22261	♀	Cerro Viejo Camp	2000 Feet	March 8, 1932

*Feet orange.

Corapipo altera altera Hellmayr. COSTA RICAN WHITE-THROATED MANAKIN.

Compared with 25 specimens of *Corapipo altera altera* and 10 of *Corapipo altera heteroleuca*, including 2 topotypes of the latter, our specimens were found to be typical of the former subspecies.

This interesting little manakin was first encountered in the mountain forests when we had reached an elevation of 1500 feet at Altos Cacao. It was fairly common there, and even more so around Cerro Viejo camp at 2000 feet. It was also found at 3000 feet near our camp at Cavulla.

The curious "dance" of the males of this species was observed on several occasions. Attention was usually first called to the presence of the bird by a muffled, explosive "puff," like a miniature blast of dynamite going off underground. The bird was never observed while making this sound for the first time, so whether it was made while the bird was perching or while on the wing, cannot be said, but on two occasions the manakin was seen in flight directly after the sound was heard, moving very slowly and evenly through the air on rapidly vibrating wings which produced a dis-

tinct humming sound, and with white throat-patch puffed out, so that at first glance it appeared as if the bird were carrying a white chicken feather in its beak. During the course of this peculiar slow progress from one perch to another, on one occasion for a distance of some fifty feet, the tiny explosions were repeated 2 or 3 times. It seems that the sounds must have been made with the wings in the same manner that hummingbirds frequently cause a sudden explosive increase in the volume of the humming sound of their wings. As far as could be determined these display antics were solo affairs. At neither time the dance was observed, was the presence of another bird of the same species detected, and certainly if others were present they did not join in the dance as is the case with the sharp-tailed manakin.

It seems evident that males of this species breed while still in the immature plumage, since one was captured in immature garb on March 1, which had much enlarged gonads.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22278	♂	Altos Cacao	1500 Feet	February 28, 1932
22279	♂	Altos Cacao	1500 Feet	February 28, 1932
22285*	♂ im.	Altos Cacao	1500 Feet	March 1, 1932
22286	♀	Altos Cacao	1500 Feet	March 3, 1932
22280	♂	Altos Cacao	1500 Feet	March 5, 1932
22281	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932
22282	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932
22283	♂	Cerro Viejo Camp	2000 Feet	March 9, 1932
22287	♂ im.	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22284	♂	Cerro Viejo, Cavulla	3000 Feet	March 14, 1932

*Testes well developed.

Manacus aurantiacus flaviventris, subsp. nov. YELLOW-BELLIED MANAKIN.

Subspecific Characters.—Similar to *Manacus aurantiacus aurantiacus*, but more brightly colored; male with throat, sides of head, and hind-neck, deeper and more extensively orange; posterior under parts of a brighter yellow (less washed with olive green); female, with yellow on the abdomen brighter and more extensive; throat more yellowish olive green; a more distinct band of darker olive green on the chest; upper parts slightly more yellowish olive green.

Measurements.—*Adult male* (5 specimens from the Azuero Peninsula): wing, 48-49 (average, 48.7) mm.; tail, 30-31 (30.6); exposed culmen, 10-11 (10.7); tarsus, 19-21 (20.3). *Adult female* (5 specimens from the Azuero Peninsula): wing, 48-51.5 (50.5); tail, 30-33.5 (32.5); exposed culmen, 9-11 (10.2); tarsus, 18-19.5 (19.2).

Type.—Adult female, No. 22264, Cleveland Museum of Natural History; Mariato River, elevation 250 feet; 10 miles east of Montijo Bay, Veraguas, Panama; February 22, 1932; John W. Aldrich, original number 1792.

Geographic Distribution.—As far as is known at present, confined to the Azuero Peninsula, southern Veraguas, Panama.

Remarks.—Compared to 20 specimens of *Manacus aurantiacus aurantiacus* from Chiriqui, western Panama, and southwestern Costa Rica, including 10 specimens from Divala which is very near the type locality (Bugaba), the Azuero Peninsula series is very distinct. The females of this species show greater geographic variation than the males, and for this reason a female was chosen as the type of *Manacus aurantiacus flaviventris*. The females of the new form are very distinctly brighter and more extensively yellow on the abdomen, this color extending anteriorly on to the breast. The throat of *M. a. flaviventris* is much paler and more yellowish olive green than in typical *M. a. aurantiacus*, in which the throat is more nearly the same color as the breast. For this reason the former subspecies seems to have a distinct dark band across the chest. In the male the most noticeable difference is the brighter more yellowish color of the posterior under parts of the new subspecies.

Since no Veraguas birds have been seen other than those from the Azuero Peninsula, it is impossible to say, at the present time, how extensive is the range of *M. a. flaviventris*. All Chiriqui and Costa Rica examples seen are referable to *M. a. aurantiacus*.

The writer agrees with Hellmayr[97] that *Manacus aurantiacus* is probably conspecific with *Manacus vitellinus*, but the characters of *M. a. flaviventris*, instead of giving any further indication of intergradation between the 2 forms, vary from the characters of *M. a. aurantiacus* in the opposite direction from those of *M. v. vitellinus* of the Canal Zone. Therefore, if the intergradation does occur it

[97]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VI, November 14, 1929, p. 73.

would seem that it must be in the interior of Panama north of the Azuero Peninsula, in Veraguas or Coclé. The possibility of this is indicated by the specimen of *M. v. vitellinus* from Chorera in the western part of the Province of Panama a short distance west of the Canal Zone, noted by Chapman.[98] This was a male in which the orange areas were more deeply colored.

The yellow-bellied manakin was a common bird in the dense undergrowth of the bottomland forest at Paracoté, and the forest borders at Mariato River camp and Altos Cacao. It seems to be absent from the deeper forest areas and from the higher altitudes.

The curious snapping sounds produced by this species are evidently similar to those described for the Gould manakin (*Manacus vitellinus vittellinus*) by Chapman[99] and might be considered another indication of the close relationship between these two forms.

On one occasion a very brief glimpse was obtained of the dance of this species. Attention was attracted to the presence of a male yellow-bellied manakin by the familiar snapping sounds issuing from an extremely dense thicket into which the writer was able to see with great difficulty. Through the dense maze of vines and twigs I caught sight of one of the brilliant little orange and black fellows hopping around and around a triangular course on the floor of the thicket. Each hop carried the bird over one side of an equilateral triangle, approximately two feet on a side. Each hop occurred at rhythmic intervals of about one second each and was accompanied by a flit of the wings and a loud snap. The sound was presumably caused by the wings in the same manner as that described by Chapman[99] for the Gould manakin.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22262*	♀	Paracoté	Sea Level	February 5, 1932
22263*	♂	Paracoté	Sea Level	February 6, 1932
22264	♀	Mariato River Camp	250 Feet	February 22, 1932
22265	♂	Altos Cacao	1500 Feet	March 3, 1932
22266	♀	Altos Cacao	1500 Feet	March 4, 1932
22267	♂	Altos Cacao	1500 Feet	March 5, 1932
22268	♂	Altos Cacao	1500 Feet	March 5, 1932
22269	♀	Paracoté	1500 Feet	March 25, 1932

*Feet bright orange.

[98]Bull. Amer. Mus. Nat. Hist., Vol. XXXVI, 1917, p. 487.
[99]Bull. Amer. Mus. Nat. Hist., Vol. LXVIII, September 30, 1935, p. 491.

Schiffornis turdinus verae-pacis (Sclater and Salvin). BROWN MANAKIN.

This series averages somewhat more greenish both above and below than specimens from Guatemala and Costa Rica, thus seeming to substantiate the validity of *Schiffornis turdinus dumicola* Bangs. However, since Hellmayr[100] states that he has seen 6 birds from the coastal forests of the Pacific side of Veraguas, including 3 from Cerro Montuosa on the Azuero Peninsula, which approach *S. t. furvus* (a more brownish form than *S. t. verae-pacis*), I am inclined to follow the example of several other authors and tentatively consider *S. t. dumicola* a synonym of *S. t. verae-pacis*. On the other hand, there does not at present seem to be a large enough series in existence from western Panama, to make possible a definite statement that *S. t. dumicola* is unrecognizable on the basis of average differences.

This species was rather common in the undergrowth of the more heavily forested regions at all elevations visited, but because of tis secretive habits would usually have been overlooked had it not been for its rather musical calls.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22243	♀	Mariato River Camp	250 Feet	February 21, 1932
22244	♀	Mariato River Camp	250 Feet	February 23, 1932
22245	♂	Altos Cacao	1500 Feet	February 28, 1932
22246	♂	Altos Cacao	1500 Feet	February 28, 1932
22247	♂	Altos Cacao	1500 Feet	March 5, 1932
22248	♂	Cerro Viejo, Cavulla	3000 Feet	March 14, 1932
22249	♂	Paracoté	Sea Level	April 1, 1932

Muscivora tyrannus (Linnaeus). FORK-TAILED FLYCATCHER.

A single individual of this species was observed to alight on the ground in the open yard beside our house on the plantation at Paracoté. Before the bird could be collected, however, it took wing and flew straight away toward the northwest and did not stop until completely out of sight in the distance. The fork-tailed flycatcher was found to be a very common species on the dry, grassy plains of Coclé Province through which we traveled to reach the

[100]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VI, November 14, 1929, p. 86.

Azuero Peninsula. It is believed, however, that the single bird seen at Paracoté, was not a resident there, but probably a straggler from the more characteristic habitat offered by the savannahs of Panama, north of the Azuero Peninsula.

Tyrannus melancholicus chloronotus Berlepsch. BERLEPSCH KINGBIRD.

The Azuero Peninsula specimens collected are indistinguishable from Costa Rican individuals.

This kingbird was one of the commonest and most conspicuous birds in the more open, scrubby country in the vicinity of the cocoanut plantation, and in the cultivated lands about the houses. It was absent, however, from habitat of similar appearance in the mountains.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22309	♂	Paracoté	50 Feet	February 7, 1932
22310	♀	Paracoté	50 Feet	February 7, 1932
22311	♂	Paracoté	50 Feet	February 9, 1932
22312	♂	Paracoté	50 Feet	March 25, 1932
22313	♂	Paracote	50 Feet	April 1, 1932

Legatus leucophaius leucophaius (Vieillot). STRIPED FLYCATCHER.

Not having seen any topotypical specimens of this form from Cayenne the writer cannot say whether our 2 specimens are typical of *Legatus leucophaius leucophaius* or not. They differ markedly from a single example from western Costa Rica in being distinctly more yellowish and less heavily streaked below; also in being more greenish, less brownish on the back. However, in a species known to exhibit so much individual variation as does *Legatus leucophaius* our series is far too small to permit any definite conclusions.

The striped flycatcher was encountered only twice on our trip and was evidently not common.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22340	♀	Mariato River Camp	250 Feet	February 23, 1932
22241	♂	Paracoté	Sea Level	March 22, 1932

Myiodynastes maculatus nobilis Sclater. NOBLE FLYCATCHER.

Despite the opinions of several other authors[101] to the contrary, the writer, after having examined 55 specimens of *Myiodynastes maculatus* from Brazil, Trinidad, Colombia, Panama, and Costa Rica, is of the opinion that *M. m. nobilis* is easily separable from *M. m. maculatus* on the basis of size, and of the color of either the upper or under parts, in most cases both. Santa Marta, Colombia the type locality of *M. m. nobilis*, is unfortunately in an intermediate area as far as color variation is concerned, the most marked and constant color differences from those of typical *M. m. maculatus* being found in examples from Panama and Costa Rica, including our Azuero Peninsula specimens, which exhibit extreme *nobilis* characters both in size and color.

There seem to be 2 color phases in *Myiodynastes maculatus* irrespective of sex. In one the buffy edges of the back feathers are cinnamon buff, while in the other they are yellowish buff occasionally tinged with green. There seems to be no racial significance to these differences, as both phases, with all kinds of intergradation exhibited, are found throughout the range of the species. The character of the color of the upperparts which distinguishes *M. m. nobilis* from *M. m. maculatus* is not the color of the edges of the feathers, but the relative amount of dark brown center and paler buff edging. The darker appearance of *M. m. maculatus* is due to the greater size of the dark brown centers of the dorsal feathers. The yellowish cast of the under parts is subject to a great deal of individual variation in this species, but *M. m. nobilis* averages a little more yellowish than *M. m. maculatus*. Two eastern Panama (Port Obaldia and Mt. Sapo) birds are the most yellowish below. The amount of streaking on the under surface is subject to considerable individual variation, but apparently has very little value for racial discrimination.

Myiodynastes maculatus nobilis, judging from the specimens at hand, reaches its maximum size in western Panama, and averages distinctly larger than *M. m. maculatus*, as may be seen from the following measurements:

[101] Todd and Carriker, Ann. Carnegie Mus., Vol. XIV, October, 1922, pp.344-345.
Chapman, Bull. Amer. Mus. Nat. Hist., Vol LV, October 1, 1926, p. 512.
Griscom, Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 8, April, 1929, p. 176.
Griscom, Bull. Mus. Comp. Zoöl., Vol. LXXII, No. 9, January, 1932, p. 350.

Myiodynastes maculatus maculatus.—Adult male (4 specimens from Para and Amazonas, Brazil): wing, 102-105 (average, 103) mm.; tail, 75-81 (78.5); exposed culmen, 19-21 (20.3); tarsus, 18-20 (19). *Adult female* (2 specimens from Para and Serra da Lua, Brazil): wing, 96-106 (average, 101) mm.; tail, 75-82 (78.5); exposed culmen, 20-23 (21.5); tarsus, 18-21 (19.5).

Myiodynastes maculatus nobilis.—Adult male (26 specimens from Santa Marta, Colombia; central and western Panama; and southwestern Costa Rica): wing, 104-116 (average, 108.5) mm; tail, 81-90 (84.9) exposed culmen, 20-25 (22.8); tarsus, 18-22 (19.7). *Adult female* (19 specimens from Santa Marta, Colombia; eastern, central, and western Panama; and southwestern Costa Rica): wing, 98-111 (average, 105.8) mm.; tail, 76-88 (83.4); exposed culmen, 19-25 (22.2); tarsus, 18-21 (19.9).

The noble flycatcher was a very common species in the more open scrubby country of the Azuero Peninsula lowlands in the vicinity of the cocoanut plantation. A pair was observed nesting in an abandoned woodpecker nesting cavity in a small dead tree at the edge of our camp clearing at Altos Cacao.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22288	♀	Paracoté	50 Feet	February 5, 1932
22289	♀	Paracoté	50 Feet	February 7, 1932
22290	♂	Paracoté	50 Feet	February 8, 1932
22291	♂	Paracoté	50 Feet	February 14, 1932
22292	♀	Altos Cacao	1500 Feet	February 28, 1932

Megarhynchus pitangua mexicanus (Lafresnaye). MEXICAN BOAT-BILLED FLYCATCHER.

The 2 specimens collected were the only individuals of this big flycatcher seen on the entire trip. They were found in the scrubby savannah country at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22293	♂	Paracoté	50 Feet	February 18, 1932
22294	♂	Paracoté	50 Feet	March 29, 1932

Myiozetetes cayanensis harterti Bangs and Penard. HARTERT FLYCATCHER.

Our 2 specimens collected on the Azuero Peninsula, Panama, extend the known range of this species westward to that point from the Panama Canal Zone. Compared with a male and a female from Loma del Leon, Panama, including the type of *Myiozetetes cayanensis harterti*, our Azuero Peninsula specimens seem to be perfectly typical of that subspecies.

The collected specimens were the only individuals of this species seen. These were evidently a pair as they were taken together in rather open scrubby country near the shore of Montijo Bay.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22318	♂	Paracoté	Sea Level	February 15, 1932
22319	♀	Paracoté	Sea Level	February 15, 1932

Myiozetetes similis columbianus Cabanis and Heine. COLOMBIAN FLYCATCHER.

A single specimen was taken at Mariato River camp in a region at that time entirely devoid of clearings, and not the type of country where one would expect to find this species. It was not encountered in the lowland savannahs which seemed to offer a more characteristic habitat for this species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22320	♂	Mariato River Camp	250 Feet	February 24, 1932

Myiarchus crinitus boreus Bangs. NORTHERN CRESTED FLYCATCHER.

Crested flycatchers were seen on several occasions both in the woodlands bordering the plantation and in the forested region of the interior of the Azuero Peninsula. The 2 specimens collected were molting the feathers of the throat, and the bird taken on February 8 was molting the tail also.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22303	♀	Paracoté	50 Feet	February 8, 1932
22304	♀	Altos Cacao	1500 Feet	February 28, 1932

Myiarchus ferox panamensis Lawrence. PANAMA FLYCATCHER.

Our series from the Azuero Peninsula is indistinguishable from a series of typical *Myiarchus ferox panamensis* from the Canal Zone.

The Panama flycatcher was a common bird in the more open scrubby country at Paracoté. It was found also in the openings in the highlands up to 3000 feet.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22305	♀	Cerro Viejo, Cavulla	3000 Feet	March 14, 1932
22306	♀	Paracoté	50 Feet	March 27, 1932
22307	♂	Paracoté	50 Feet	February 9, 1932
22308	♂	Paracoté	50 Feet	February 13, 1932

Myiarchus tuberculifer brunneiceps Lawrence. BROWN-CAPPED FLYCATCHER.

Compared with a series of *Myiarchus tuberculifer bangsi* from southwestern Costa Rica and Chiriqui, Panama, and a series of *M. t. brunneiceps* from the Canal Zone, Panama, our specimens, although intermediate, appear closer to the latter. The color of the back is slightly more brownish than in typical *M. t. brunneiceps*, but closer to that form in this character than to *M. t. bangsi*. With respect to the amount of rufous edgings on the secondaries and wing coverts the Azuero Peninsula birds are almost exactly intermediate between *M. t. brunneiceps*, and *M. t. bangsi;* in the amount of rufous edgings on the tail, however, they are much nearer to *M. t. brunneiceps*. With respect to the color of the head the Azuero Peninsula series is also nearer to *M. t. brunneiceps* than to *M. t. bangsi*, although not much credit is given to this character since it is found to vary greatly with the age of the skins.

The brown-capped flycatcher was rather common and evenly distributed throughout the forest from sea level to an altitude of 3000 feet.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22295	♂	Paracoté	50 Feet	February 5, 1932
22296	♂	Paracoté	50 Feet	February 12, 1932
22297	♀	Paracoté	50 Feet	February 12, 1932
22298	♂	Altos Cacao	1500 Feet	February 28, 1932
22299	♂	Altos Cacao	1500 Feet	March 1, 1932
22300	..	Altos Cacao	1500 Feet	March 1, 1932
22301	♀	Cerro Viejo Camp	2000 Feet	March 6, 1932
22302	♀	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932

Empidonax flaviventris (Baird). YELLOW-BELLIED FLYCATCHER.

The single specimen of this North American migrant collected in the forest at Paracoté was molting both wing and head feathers.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22354	♂	Paracoté	50 Feet	March 25, 1932

Terenotriccus erythrurus fulvigularis (Salvin and Godman). FULVOUS-THROATED FLYCATCHER.

The 2 males collected on the same day in the forest along the Mariato River represent our total experience with this species on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22350	♂	Mariato River Camp	250 Feet	February 25, 1932
22351	♂	Mariato River Camp	250 Feet	February 25, 1932

Myiobius atricaudus atricaudus Lawrence. BLACK-TAILED MYIOBIUS.

The 4 specimens of this species collected on the Azuero Peninsula differed very slightly from 12 topotypical and nearly topotypical specimens of *Myiobius atricaudus atricaudus* from the Canal Zone, in being paler and more yellowish olive green on the back and pileum; in having the chest more tawny, less grayish; and the abdomen of a brighter yellow. However, at the present time it is thought that the differences are too slight to warrant subspecific separation.

Peters[102] has called attention to a skeletal peculiarity of *Myiobius sulphureipygius aureatus* in that the adult has a non-ossified skull. This same characteristic was found in all of our specimens of *Myiobius atricaudus atricaudus*.

The black-tailed myiobius was apparently of rather localized distribution on the Azuero Peninsula, since 4 specimens were taken at Mariato River camp and the species was not encountered at any other forest locality.

Because of its habit of flitting about among the lower branches of the trees with tail spread, this little flycatcher reminded the writer of the more familiar North American redstart (*Setophaga ruticilla*).

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22356*†	♀	Mariato River Camp	250 Feet	February 21, 1932
22357*	♂	Mariato River Camp	250 Feet	February 22, 1932
22358*	♀	Mariato River Camp	250 Feet	February 24, 1932
22359	♂	Mariato River Camp	250 Feet	February 26, 1932

*Skull very soft.
†Ovary developed.

Tolmomyias sulphurescens flavo-olivaceus (Lawrence). YELLOW-OLIVE FLYCATCHER.

The capture of a single female of this species in the heavy forest bordering the Mariato River is all the knowledge that can be contributed concerning the distribution of the yellow-olive flycatcher on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22353	♀	Mariato River Camp	250 Feet	February 25, 1932

Rhynchocyclus brevirostris brevirostris (Cabanis). SHORT-BILLED FLYCATCHER.

The four specimens of this species collected on the Azuero Peninsula are identical with a series from Boquete and Volcan de Chiriqui, western Panama which have been referred by various

[102]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 12, October, 1929, p. 449.

authors to *Rhnchocyclus brevirostris brevirostris*. The Azuero Peninsula birds show no tendency toward intergradation with specimens of *Rhynchocyclus brevirostris hellmayri* from eastern Panama.

The short-billed flycatcher like the black-tailed myiobius (*Myiobius atricaudus atricaudus*) was apparently of rather localized distribution on the Azuero Peninsula since 4 specimens were taken in the heavy forest at Mariato River Camp and the species was not encountered at any other collecting station.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22314	♀	Mariato River Camp	250 Feet	February 22, 1923
22315	..	Mariato River Camp	250 Feet	February 23, 1932
22316	..	Mariato River Camp	250 Feet	February 24, 1932
22317	♂	Mariato River Camp	250 Feet	February 26, 1932

Atalotriccus pilaris wilcoxi Griscom. WILCOX PIGMY TYRANT.

The single specimen taken at the edge of the forest at Paracoté represents the extent of our knowledge of the distribution of this species on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22352*	..	Paracoté	Sea Level	February 17, 1932

*Iris yellowish white.

Elaenia flavogastra pallididorsalis subsp. nov. PANAMA ELAENIA.

Subspecific Characters.—Similar to *Elaenia flavogastra flavogastra*, but averaging slightly paler above; much more yellowish below. Similar also to *Elaenia flavogastra subpagana*, but slightly less yellowish on posterior under parts and paler grayish on the chest; upper parts averaging very much paler and less brownish (more grayish or greenish) olive green.

Measurements.—Adult male (27 specimens from the Azuero Peninsula, Pearl Islands, and Pacific side of the Isthmus of Panama): wing, 75-84.5 (average 79.9) mm.; tail, 68-79 (73.5); exposed cul-

men, 10-12.5 (11.3); tarsus, 18.5-21 (19.9). *Adult female* (16 specimens from the Pearl Islands and the Pacific side of the Isthmus of Panama): wing, 70-80 (average, 76.9) mm.; tail, 66-76 (71.7); exposed culmen, 10-12 (10.8); tarsus, 18-21 (19.5).

Type.—Adult male, No. 22322, Cleveland Museum of Natural History; Paracoté, altitude 50 feet, east shore of Montijo Bay, 1 mile south of the mouth of the Angulo River, Veraguas, Panama; February 8, 1932; John W. Aldrich, original number, 1660.

Geographic Distribution.—Savannahs and clearings on the Pacific slope of Panama, including the Azuero Peninsula and the Pearl Islands.

Remarks.—With a series of 86 specimens of *Elaenia flavogastra*, containing birds from regions ranging from Mexico to Brazil available for comparison it is perfectly obvious that, despite considerable individual variation, the birds from the Pacific side of Panama and from the Pearl Islands average paler and less brownish above than the examples from Costa Rica northward. Birds from the Pearl Islands and near Panama City are paler and more grayish, while specimens from the Azuero Peninsula are paler and more greenish than those from Costa Rica northward in Central America which are assumed to be typical *Elaenia flavogastra subpagana*. Ridgway[103] noted the pallor of the upper parts of specimens of this species from Saboga Island and the vicinity of Panama City and suggested that they might possibly represent a new form. He did not, however, suggest a new name for them.

Specimens from the Atlantic side of the Canal Zone and those from the Pacific side of extreme western Panama are somewhat intermediate between *E. f. subpagana* and *E. f. pallididorsalis*. The former, however, seem nearer *E. f. subpagana*, while the latter average closer to *E. f. pallididorsalis*. A single specimen from Cana, eastern Panama is, as Griscom[104] says intermediate between Central American birds of this species and *E. f. flavogastra*. However, in view of the above proposed separation of a new form from the Pacific slope of Panama, it is the writer's opinion that this specimen should be referred to *E. f. pallididorsalis*, although somewhat darker on the upper parts and paler below than the average of that sub-species.

[103]Bull. U. S. Nat. Mus., No. 50, Part IV, July 1, 1907, p. 430.
[104]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 8, April, 1929, p. 175.

While *E. f. pallididorsalis* appears somewhat intermediate between *E. f. subpagana* and *E. f. flavogastra* in respect to the color of the under surface, it is not intermediate in the color of the upper parts, which are paler in *E. f. pallididorsalis* than in either of the two other forms.

The Panama elaenia was in the field, not distinguished from the Lawrence elaenia (*Elaenia chiriquensis*) with which it associated in the open scrubby land on the plantation, so on that basis, it is impossible to say what was the relative abundance of the former species on the Azuero Peninsula. It can be said only that out of 13 specimens of both species collected at random on the plantation, but 2 turned out to be the Panama elaenia. A single specimen of this species was seen and collected on the mountain savannahs at Cavulla, near the top of Cerro Viejo.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22321	♂	Paracoté	50 Feet	February 5, 1932
22322	♂	Paracoté	50 Feet	February 8, 1932
22323	♂	Cerro Viejo, Cavulla	3000 Feet	March 12, 1932

Elaenia chiriquensis chiriquensis Lawrence. LAWRENCE ELAENIA.

No difference can be detected between the series of *Elaenia chiriquensis* from the Azuero Peninsula and specimens from El General, Costa Rica, indicating that birds of this species from the former region are probably fairly typical *E. c. chiriquensis*.

The Lawrence elaenia was a very common bird in the open scrubby country adjoining the cocoanut plantation at Paracoté, apparently considerably outnumbering the Panama elaenia (*Elaenia flavogastra pallididorsalis*) with which it associated (see preceding species). Two specimens were taken in the mountains in brush grown areas which had formerly been under cultivation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22324	♂	Paracoté	50 Feet	February 5, 1932
22325	♂	Paracoté	50 Feet	February 6, 1932
22326	♂	Paracoté	50 Feet	February 7, 1932
22327	♀	Paracoté	50 Feet	February 7, 1932
22328	♂	Paracoté	50 Feet	February 8, 1932
22329	♂	Paracoté	50 Feet	February 8, 1932
22330	♀	Paracoté	50 Feet	February 12, 1932
22331	♂	Paracoté	50 Feet	February 18, 1932
22332	♀	Paracoté	50 Feet	February 18, 1932
22333	..	Paracoté	50 Feet	February 18, 1932
22334	♂	Altos Cacao	1500 Feet	March 5, 1932
22335	..	Cerro Viejo, Cavulla	3000 Feet	March 11, 1932
22336	♀	Paracoté	50 Feet	March 22, 1932

Elaenia viridicata accola (Bangs). PANAMA PLACID ELAENIA.

Although our 3 specimens of this species seem darker than the average of 26 topotypical examples of *E. v. accola*, the difference seems too slight to differentiate them subspecifically, particularly in view of the fact that only 2 of the specimens from the Azuero Peninsula are adults.

A report of the 3 specimens collected in the forest at three widely separated collecting stations is the only information that can be contributed concerning the distribution of the Panama placid elaenia on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22337	♀	Mariato River Camp	250 Feet	February 21, 1932
22338	..juv.	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22339	♂	Paracoté	Sea Level	March 29, 1932

Tyranniscus vilissimus parvus Lawrence. LESSER PALTRY FLYCATCHER.

Our single specimen from the Azuero Peninsula is slightly paler and more yellowish olive green on the upper parts, also brighter and more extensively yellow on the posterior under surface than 3 typical specimens of *Tyranniscus vilissimus parvus* from the Canal Zone, as well as 1 specimen from Cana, eastern Panama, and 2 from El General, Costa Rica. A larger series from the Azuero Peninsula might show the birds from that region worthy of separation.

Our entire knowledge of the distribution of the lesser paltry flycatcher in the regions visited is represented by the single specimen collected in the lowland forest at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22355	♂	Paracoté	Sea Level	February 7, 1932

Pipromorpha oleaginea lutescens Griscom. VERAGUAS PIPROMORPHA.

Our Azuero Peninsula series is slightly duller on the under parts, being less greenish anteriorly, and less yellowish, more tawny posteriorly, than 4 topotypical specimens of *Pipromorpha oleaginea lutescens* from Santa Fé, Veraguas. This condition was noted also by Griscom[105] in specimens from the coastal forests of Veraguas. However, the writer agrees with Griscom that these southern Veraguas birds, which include those from the Azuero Peninsula are, despite a slight average difference, best referable to *P. o. lutescens*.

The Veraguas pipromorpha was a rather common species in the forests at the higher altitudes on the Azuero Peninsula. We encountered these birds frequently in the undergrowth of the forests about 1500 feet. It was most abundant at 3000 feet, the highest of our collecting stations.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22342	♀	Mariato River Camp	250 Feet	February 23, 1932
22343	♂	Altos Cacao	1500 Feet	February 28, 1932
22344	♀	Altos Cacao	1500 Feet	February 28, 1932
22345	♂	Altos Cacao	1500 Feet	March 3, 1932
22346	♂	Cerro Viejo Camp	2000 Feet	March 6, 1932
22347	♂	Cerro Viejo Cavulla	3000 Feet	March 13, 1932
22348	♂	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22349	..	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932

There are in the American Museum of Natural History 2 male specimens[106] collected by Rex Benson in the interior of the Cape Mala [=Azuero] Peninsula.

Iridoprocne albilinea (Lawrence). MANGROVE SWALLOW.

The mangrove swallow was a common bird along the shore of Montijo Bay. Several individuals were always to be seen coursing back and forth either along the beach, or over the water of the

[105]Amer. Mus. Novit., No. 280, September 10, 1927, p. 10.
[106]Griscom, Amer. Mus. Novit., No. 280, September 10, 1927, p. 10.

estero, or of a partially dried up lagoon where the 2 specimens were taken at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22360	♂	Paracoté	Sea Level	February 15, 1932
22361	♀	Paracoté	Sea Level	February 15, 1932

Cyanocorax affinis zeledoni Ridgway. TALAMANCA JAY.

Three roving bands of these jays were encountered in the forests of the Azuero Peninsula. Two of them were at Paracoté and one at Mariato River camp. The bands consisted of from 6 to 10 birds each.

The Talamanca jay is apparently endowed with considerable curiosity. On each occasion the birds hovered all about in the trees giving voice to a great variety of squeaks and rattling sounds as they eyed me curiosly.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22362*	♂	Paracoté	50 Feet	February 5, 1932
22363*	♀	Paracoté	50 Feet	February 5, 1932

*Iris straw yellow.

Thryothorus rufalbus castanonotus (Ridgway). CHESTNUT-BACKED WREN.

No difference can be detected between our two specimens and a series of 6 supposedly typical examples of *Thryothorus rufalbus castanonotus* from Costa Rica.

The specimens were taken in the dense forest undergrowth, one in the heavy timber along the Mariato River, 10 miles from the coast, and the other in the woods adjoining the cocoanut plantation at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22373	♂	Mariato River Camp	150 Feet	February 24, 1932
22374	♀	Paracoté	50 Feet	April 2, 1932

Thryothorus modestus elutus (Bangs). PANAMA WREN.

There has been available for the present study a large series of specimens of *Thryothorus modestus* from the Canal Zone, Panama and Costa Rica including topotypes of both *T. m. modestus* and *T. m. elutus*. This seems to be a species subject to great variation in color due to abrasion of the plumage. Worn plumaged Costa Rican specimens of *T. m. modestus* can scarcely be distinguished from equally abraded Canal Zone specimens of *T. m. elutus*. Unabraded Costa Rican specimens are distinctly darker and more reddish brown on the back than fresh plumaged Canal Zone birds. Our specimen from the Azuero Peninsula which is in good condition is fairly typical *T. m. elutus*, although somewhat darker and more reddish on the back than the average of Canal Zone specimens.

The single specimen of the Panama wren obtained was discovered in the rank growth of sprouts growing up in a small patch of fallow cultivated land at Altos Cacao.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22375	♀	Altos Cacao	1500 Feet	March 2, 1932

Thryothorus rutilus hyperythrus Salvin and Godman. TAWNY-BELLIED WREN.

Our Azuero Peninsula series was found to differ from a series of 7 typical specimens of *Thryothorus rutilus hyperythrus* from the Canal Zone in having a considerably more brownish, less grayish back; larger white spots on sides of head and throat; under parts of a brighter rufous, and in entirely lacking white on the center of the abdomen. Since, however, the two series are not comparable in respect to season, the Azuero Peninsula birds having been taken in the winter, and the Canal Zone specimens in the summer, the writer does not place a great deal of confidence in the significance of the differences noted. Mr. B. P. Bole, Jr., took our Azuero Peninsula specimens to the Museum of Comparative Zoölogy where he and Mr. James L. Peters very kindly compared them with much larger series from the Canal Zone as well as other parts of the range of *T. r. hyperythrus*. He discovered that, although there is a

slight tendency for Costa Rican and western Panama (including Azuero Peninsula) birds to have darker under parts than seasonally comparable Canal Zone specimens, all of the other characters mentioned above are subject to marked seasonal change due to abrasion and are therefore of very little value as racial distinctions.

The tawny-bellied wren was a rather common species in the heavily forested regions of the Azuero Peninsula, particularly along the banks of the Mariato River. Its long rich song frequently called attention to its presence.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22364	♂	Mariato River Camp	250 Feet	February 21, 1932
22365	♂	Mariato River Camp	250 Feet	February 21, 1932
22366	♂	Mariato River Camp	250 Feet	February 23, 1932
22367	♂	Altos Cacao	1500 Feet	February 28, 1932
22368	♀	Altos Cacao	1500 Feet	February 29, 1932
22369	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932

Troglodytes musculus inquietus Baird. PANAMA HOUSE WREN.

Our 3 Azuero Peninsula specimens have not been compared with topotypical *Troglodytes musculus inquietus* from the Canal Zone. They are, however, not different from 2 specimens from Divala, western Panama, from which region birds have been referred by several authors to *T. m. inquietus*.

The Panama house wren was a common bird about the cocoanut plantation, particularly in the vicinity of the buildings. Its song and habits were extremely like the more familiar North American house wrens (*Troglodytes domesticus*). On two occasions a bird of this species was trapped in our screened porch, coming in through a knot hole under the eaves and being unable to find its way out again.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22370	♂	Paracoté	Sea Level	February 12, 1932
22371	♂	Paracoté	Sea Level	March 23, 1932
22372	♀	Paracoté	Sea Level	March 23, 1932

Dumetella carolinensis (Linnaeus). CATBIRD.

The well known mewing note of this species, issuing from a dense tangle of bushes and vines at the edge of the road at Paracoté, first called attention to the presence of this familiar North American migrant.

By reason of the paucity of Panama records for the catbird, except in the Almirante region, indicated by Griscom,[107] the capture of an additional specimen seems to be of considerable interest. The species was not met with on the Azuero Peninsula except as mentioned above; and Paracoté apparently constitutes the farthest south locality at which the catbird has ever been taken.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22376	..	Paracoté	50 Feet	March 22, 1932

Turdus assimilis cnephosus (Bangs). SALVIN THRUSH.

Our series of this species collected on the Azuero Peninsula was compared with 33 specimens of *Turdus assimilis cnephosus* from western Panama and Costa Rica, including 4 topotypical specimens of this race from Boquete. Only 1 out of 7 of the Azuero Peninsula birds differs appreciable from typical *T. a. cnephosus*. This individual is more brownish (less olivaceous) above, more brownish (less grayish) below, and apparently shows a tendency toward intergradation with *Turdus assimilis daguae* of Colombia and eastern Panama.

Salvin thrushes were in full song and much in evidence during our trip into the mountains in late February and March. The species was first encountered at Mariato River camp at 250 feet elevation, but became more abundant as we ascended the mountains. It reached its peak of abundance at our highest camp, Cavulla, near the top of Cerro Viejo at 3000 feet elevation. There, these thrushes were very common and their loud caroling songs, very similar to those of the familiar North American robin (*Turdus migratorius*), were the most characteristic sounds of the misty, moss-festooned, subtropical forest.

[107]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April, 1935, p. 360.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22384*	♂	Mariato River Camp	250 Feet	February 22, 1932
22385*	♂	Mariato River Camp	250 Feet	February 22, 1932
22386*	♂	Cerro Viejo Camp	2000 Feet	March 6, 1932
22387*	♂	Cerro Viejo Camp	2000 Feet	March 7, 1932
22388	♂	Cerro Viejo Cavulla	3000 Feet	March 13, 1932
22389	♂	Cerro Viejo Cavulla	3000 Feet	March 14, 1932
22390	♂	Cerro Viejo Cavulla	3000 Feet	March 14, 1932

*Eyelids yellow.

Turdus grayi casius (Bonaparte). BONAPARTE THRUSH.

Our specimens from the Azuero Peninsula are very close in color to those from David, Chiriqui, also to those from near Panama City.

The Bonaparte thrush was a very common bird along the forest margins at Paracoté. In the deep forests, however, and even in the openings at the higher elevations, it was absent. A single specimen only was obtained away from the vicinity of the plantation and that was in a second growth jungle on the site of the old rubber operations headquarters near our Mariato River camp.

Since this species was in full song and a female collected on March 22 contained well-developed eggs, it is assumed that our collecting fell within the breeding season. The song is similar to that of the preceding species (*Turdus assimilis*) and to the American Robin (*Turdus migratorius*), but somewhat weaker then either.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22377	♂	Paracoté	Sea Level	February 9, 1932
22378	♂	Paracoté	Sea Level	February 9, 1932
22379	♂	Paracoté	50 Feet	February 14, 1932
22380	♂	Paracoté	Sea Level	February 17, 1932
22382	♂	Paracoté	50 Feet	March 21, 1932
22383*	♀	Paracoté	50 Feet	March 22, 1932
22381	♂	Mariato River Camp	250 Feet	February 21, 1932

*Eggs well developed in ovary.

Polioptila plumbea bilineata (Bonaparte). WHITE-BROWED GNATCATCHER.

The writer here accepts the views of Hellmayr[108] in considering this form of subspecies of *Polioptila plumbea*, from which it differs

[108]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part VII, November 15, 1934, p. 501.

chiefly in the possession of white superciliary stripes. Since Griscom[109] has found that the character of the white superciliary tends to break down in Central American birds of the *bilineata* group "wherever it encounters a dry or arid climate, and disappears almost completely in western and northwestern Mexico", it would seem that intergradation is shown between *P. plumbea* and *P. bilineata* in this respect, although not necessarily over geographically continuous areas.

Our Azuero Peninsula specimens have complete white lores and superciliary stripes and are apparently typical of *P. p. bilineata*. At least they are indistinguishable from Boruca, Costa Rica, specimens, which have been referred to that form by several authors.

The white-browed gnatcatcher was not uncommon in the vicinity of the cocoanut plantation at Paracoté, 4 specimens having been collected. These birds were taken in the second growth trees at the forest margins. The species was not found away from the plantation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22391	♂	Paracoté	50 Feet	February 5, 1932
22392	♀	Paracoté	50 Feet	February 5, 1932
22393	♂	Paracoté	50 Feet	February 10, 1932
22394	♀	Paracoté	50 Feet	March 29, 1932

Ramphocaenus rufiventris sanctae-marthae Sclater. SANTA MARTA LONG-BILLED ANT-WREN.

Our 3 Azuero Peninsula specimens were compared with 4 typical examples of *Ramphocaenus rufiventris rufiventris* from Guatemala and a topotype of *Ramphocaenus rufiventris sanctae-marthae* from Santa Marta, Colombia. Our specimens are perfectly typical of the latter subspecies in size, and in degree of pallor of head and lower surface. In the degree of the brownish cast of the back they are somewhat intermediate, but nearer to *R. r. sanctae-marthae*.

This curious little long-billed ant-wren was found in the forest at 2 different camps, but was apparently not common anywhere. It recalls some species of the *Sylviidae* by its gnatcatcher-like habit of dancing stiff-legged about on its perch with tail held aloft.

[109]Amer. Mus. Novit., No. 414, March 24, 1930, pp. 6-7.

Specimens Collected

C. M. N. H. Number	Sex	Locality	Elevation	Date
22216	♂	Mariato River Camp	250 Feet	February 21, 1932
22217	..	Cerro Viejo Camp	2000 Feet	March 7, 1932
22218	♀	Cerro Viejo Camp	2000 Feet	March 8, 1932

Vireosylva flavoviridis flavoviridis (Cassin). NORTHERN YELLOW-GREEN VIREO.

A single female of this migrant form was taken at Altos Cacao, March 4, and 2 males were taken at Paracoté, March 27, 1932. All 3 of these birds are perfectly typical of *V. f. flavoviridis* in color, having well defined dusky lateral borders to the pileum, and corresponding in size to that race, as may be seen from the following measurements: (2 males) wing, 76.5, 79; tail, 53, 55; exposed culmen, 14.5,15; tarsus, 18,18; (1 female) wing, 74.5; tail, 51; exposed culmen, 13.5; tarsus, 18 mm.

This form may be conspecific with *Vireosylva olivacea* [=*virescens*] of North America as believed by Van Rossem[110] and Hellmayr[111] although the writer does not consider that this has as yet been satisfactorily established in any published work. The songs of the 2 forms are certainly strikingly similar.

Specimens Collected

C. M. N. H. Number	Sex	Locality	Elevation	Date
22395*	♀	Altos Cacao	1500 Feet	March 4, 1932
22397	♂	Paracoté	50 Feet	March 27, 1932
22398	♂	Paracoté	50 Feet	March 27, 1932

*Iris reddish brown.

Vireosylva flavoviridis insulana Bangs. SOUTHERN YELLOW-GREEN VIREO.

A single male of *Vireosylva flavoviridis insulana*, which has been shown by Peters[112] to be the breeding form of this species in Panama, was taken at Altos Cacao on March 5, 1932. This specimen has been compared with 10 individuals, including several summer examples of *V. f. insulana* from the Pearl Islands, Panama, and found to be typical in color, having the dusky lateral borders to the pileum

[110]Bull. Mus. Comp. Zoöl., Vol. LXXVII, No. 7, December, 1934, p. 467.
[111]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 132.
[112]The Auk, Vol. XLVIII, No. 4, October 18, 1931, p. 583.

scarcely discernible. In size, also, the Azuero Peninsula specimen agrees with *V. f. insulana*, as may be seen from the following measurements: wing, 75; tail, 51; exposed culmen, 14.5; tarsus, 17 mm.

When collected this specimen was in full song which was almost exactly like that of the red-eyed vireo (*Vireosylva olivacea*) of North America.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22396	♂	Altos Cacao	1500 Feet	March 5, 1932

Vireosylva philadelphica (Cassin). PHILADELPHIA VIERO.

The Philadelphia vireo was rather common in mixed flocks of arboreal North American migrants which were frequently encountered in the forests both at Paracoté and at Altos Cacao.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22399	..	Altos Cacao	1500 Feet	March 1, 1932
22400	♀	Altos Cacao	1500 Feet	March 1, 1932
22401	♂	Altos Cacao	1500 Feet	March 5, 1932

Hylophilus decurtatus decurtatus (Bonaparte). GRAY-HEADED HYLOPHILUS.

Azuero Peninsula specimens of this species seem to be indistinguishable from a large series of typical *Hylophilus decurtatus decurtatus*.

This little vireo was not uncommon in the lowland forests, where it frequented the higher leafy portions of the trees. It was not observed in any of the forests at the higher elevations, but might easily have been missed due to its inconspicuousness in the high tree tops.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22402	♂	Mariato River Camp	250 Feet	February 21, 1932
22403	♂	Paracoté	50 Feet	March 25, 1932
22404	♂	Paracoté	50 Feet	March 27, 1932
22405	♂	Paracoté	50 Feet	April 1, 1932

Coereba flaveola columbiana (Cabanis). COLOMBIAN BANANAQUIT.

As Hellmayr[113] has pointed out, Canal Zone specimens of this species are referable to *Coereba flaveola columbiana*. The writer has compared 9 adult specimens from that region with 10 examples of *Coereba flaveola mexicana* from Vera Cruz and Chiapas, Mexico, from Vera Paz, Guatemala, and from Honduras; also with 9 specimens of *Coereba flaveola columbiana* from Antioquia and Heula, Colombia, and Cana and Obaldia, eastern Panama, and finds that, particularly in the size and brightness of the yellow rump patch, the Canal Zone birds are fairly typical of the latter subspecies. At the same time our 4 adult specimens from the Azuero Peninsula were compared in the same series, and, as in the case of the Canal Zone birds, were found to be definitely referable to *Coereba flaveola columbiana*.

The Colombian bananaquit was rather common on the plantation among the cocoanut palms and in the brush at the edge of the forest.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22406	♂	Paracoté	Sea Level	February 6, 1932
22407	♀	Paracoté	Sea Level	February 8, 1932
22408	♂ im.	Paracoté	Sea Level	February 14, 1932
22409	♀ im.	Paracoté	Sea Level	February 17, 1932
22410	♀	Paracoté	Sea Level	March 23, 1932
22411	♂	Paracoté	Sea Level	April 2, 1932

Cyanerpes cyaneus carneipes (Sclater). CENTRAL AMERICAN HONEY CREEPER.

Compared to 15 specimens of typical *Cyanerpes cyaneus cyaneus* from French Guiana and Brazil, our Azuero Peninsula series, together with 4 specimens from Costa Rica, bear out perfectly the subspecific characters of *C. c. carneipes* as mentioned by Oberholser[114] and Hellmayr.[115] The broader purplish blue nuchal band of the males as well as the more yellowish under parts of the females are exceptionally well marked and constant distinguishing characters. Furthermore, the Costa Rica and Panama females are very different from the Brazil and French Guiana birds, of the same sex, in the

[113]Zoöl. Ser. Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 294.
[114]The Auk, Vol. XVI, No. 1, January, 1899, p. 33.
[115]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 256.

color of the upper parts, being much more yellowish green on the crown, back, and rump. It appears to the writer that, on the basis of specimens examined, the Central American bird is a good subspecies, and it is therefore hard to understand why several recent authors have failed to recognize it as distinct.

The Central American honey creepers apparently become concentrated in certain trees during the blooming period since all of the 10 specimens collected were taken from two adjacent trees of the same species which were, at that time, in full bloom in the forest at Altos Cacao. The birds worked about among the blossoms in the very tops of the trees and although frightened away several times by the discharge of my gun repeatedly returning to the same trees until several had been taken. This performance was repeated on 3 different days. The species was not encountered by us elsewhere.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22412*	♂	Altos Cacao	1500 Feet	March 1, 1932
22413*	♂	Altos Cacao	1500 Feet	March 1, 1932
22414†	♀	Altos Cacao	1500 Feet	March 1, 1932
22415*	♂	Altos Cacao	1500 Feet	March 3, 1932
22416*	♂	Altos Cacao	1500 Feet	March 3, 1932
22417†	♀	Altos Cacao	1500 Feet	March 3, 1932
22418*	♂	Altos Cacao	1500 Feet	March 5, 1932
22419†	♀	Altos Cacao	1500 Feet	March 5, 1932
22420†	♀	Altos Cacao	1500 Feet	March 5, 1932
22421†	♀	Altos Cacao	1500 Feet	March 5, 1932

*Feet coral red.
†Feet purplish red.

Cyanerpes lucidus isthmicus Bangs. ISTHMIAN HONEY CREEPER.

Our single specimen of this species from the Azuero Peninsula corresponds in size to *Cyanerpes lucidus isthmicus*, but is paler than the average of this form, being more like the average of *C. l. lucidus* in this respect. However, with only a single specimen at hand from the Azuero Peninsula, the writer feels that it is best to refer the birds of that region, for the present at least, to *Cyanerpes lucidus isthmicus* which is the name currently applied to Panama birds. The writer is inclined to agree with Hellmayr[116] that *Cyanerpes*

[116]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 264.

lucidus is probably a subspecies of *Cyanerpes caeruleus*, but awaits definite evidence of intergradation before recognizing this as a fact in nomenclature.

A lone male Isthmian honey creeper was taken with the 10 specimens of the Central American honey creeper in the blossoming trees at Altos Cacao, discussed under the last species. No further evidence of the occurrence of *C. l. isthmicus* on the Azuero Peninsula was found.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22422*	♂	Altos Cacao	1500 Feet	March 3, 1932

*Feet pure yellow.

Chlorophanes spiza arguta Bangs and Barbour. COSTA RICAN GREEN HONEY CREEPER.

After examination of a large series of specimens from various parts of Panama and southwestern Costa Rica, it is apparent that there is considerable variation in size and color in both males and females of the green honey creepers currently included under the name *Chlorophanes spiza arguta* Bangs and Barbour.[117] I am able to detect some slight average differences in size and color of birds from those regions which seem to be correlated with geographic distribution. However, these differences are so slight compared with the great individual variation in the birds from any one locality, that it does not seem advisable at the present time to recognize them in nomenclature. The color differences are dependent on the amount of greenish sheen of the blue plumage of the males and the degree of yellowish of the green plumage of the females. The size and color differences seem to divide the Panama and southwestern Costa Rica birds as follows:

Males

Larger and more bluish—Azuero Peninsula and (?) Pacific coast of Chiriqui.

Larger and more greenish—Southwestern Costa Rica, Atlantic slope of Chiriqui, and Canal Zone.

Smaller and more greenish—Eastern Panama.

[117]Bull. Mus. Comp. Zoöl., Vol. LXV, No. 6, September, 1922, p. 225.

Females

Larger and more pure green—Azuero Peninsula.

Larger and more yellowish green—Southwestern Costa Rica, Chiriqui, and Canal Zone.

Smaller and more yellowish green—Eastern Panama.

On the basis of these differences it would seem off-hand that 3 subspecies might be recognized in Panama. However, it does not seem advisable to recommend such a procedure at the present time, since I have been unable to see more than one topotypical specimen of *C. s. arguta*, the type itself, which is a male. A good series of both males and females from the type locality, Divala, on the Pacific coast of Chiriqui, should be studied before attempting any division of such an individually variable form. It might be stated here that the type is a very bluish individual, and could be matched in this respect, among the Panama specimens, only by males from the Azuero Peninsula. The bill is rather large (15 mm.), a character also like Azuero Peninsula specimens. The wing, on the other hand, is small (67 mm.) which equals the minimum size found among eastern Panama birds. Thus in the type, the extremes of color and size found in males are more or less bridged, which fact alone tends to preclude any subspecific differentiation until an adequate topotypical series of *C. s. arguta* can be obtained.

It might be added that the eastern Panama birds do not even vaguely suggest *C. s. subtropicalis*, the nearest form to the south, either in bluishness of males or yellowishness of females, being closer in these respects to both *C. s. exul* and *C. s. spiza*. The smaller size of the eastern Panama bird might be explained as a tendency to intergrade with the South American forms while the larger size of the western Panama specimens shows a tendency toward intergradation with *C. s. guatemalensis*.

This species seemed to be more generally distributed in the regions visited than the other species of forest-inhabiting honey creepers. Two male specimens of the Costa Rican green honey

creeper were taken with individuals of the Central American honey creeper from the same flowering trees at Altos Cacao described under the latter species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22423*	♀	Mariato River Camp	250 Fet	February 24, 1932
22424*	♀	Mariato River Camp	250 Feet	February 26, 1932
22425*	♂	Altos Cacao	1500 Feet	February 28, 1932
22426*†	♂	Altos Cacao	1500 Feet	March 5, 1932
22427	♀	Altos Cacao	1500 Feet	March 5, 1932
22428	♀	Cerro Viejo Camp	2000 Feet	March 8, 1932
22429	♂	Paracoté	50 Feet	March 25, 1932
22430	♂	Paracoté	50 Feet	April 1, 1932

*Iris red.
†Lower part of upper mandible and whole of lower mandible yellow.

Mniotilta varia (Linnaeus). BLACK AND WHITE WARBLER.

The single specimen taken was the only individual of this North American migrant encountered.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22434	♂	Paracoté	50 Feet	February 5, 1932

Protonotaria citrea (Boddaert). PROTHONOTARY WARBLER.

Several individuals of this North American migrant species were seen in a small patch of mangroves at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22435	♂	Paracoté	Sea Level	February 6, 1932

Vermivora peregrina (Wilson). TENNESSEE WARBLER.

The Tennessee warbler seemed to be the most abundant of all of the North American migrants, wintering on the Azuero Peninsula. At least the greater part of the roving flocks of warblers frequently encountered in the forest tree tops proved to be of this species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22431	..	Paracoté	50 Feet	February 8, 1932

Dendroica erithachorides aequatorialis Sundevall. PANAMA GOLDEN WARBLER.

Hellmayr[118] believes that intergradation of *Dendroica petechia* and *Dendroica erithachorides* takes place through *Dendroica ruficapilla* and considers them conspecific, with the former name taking preference due to priority. The writer does not consider that this condition has been sufficiently well established to accept in the present instance, however.

The single Azuero Peninsula specimen is indistinguishable from a large series of *D. erithachorides aequatorialis* from the Pearl Islands. It is very different from specimens of *Dendroica erithachorides erithachorides* from the Atlantic coast of Panama and *Dendroica erithachorides xanthotera* from Honduras. This extends the range of *D. e. aequatorialis* slightly westward from Agua Dulce, Coclé along the Pacific coast of Panama.

The single specimen collected and one other individual seen, both in the mangroves fringing the estero at Paracoté, represent the only records for this species on the Azuero Peninsula. Apparently the species is not common there, although it must be admitted that comparatively little time was spent collecting in the mangroves.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22436	♂	Paracoté	Sea Level	April 2, 1932

Dendroica pensylvanica (Linnaeus). CHESTNUT-SIDED WARBLER.

Although not preserved, a single specimen of the chestnut-sided warbler was taken on February 12, 1932, from one of the several roving flocks of North American migrants met with in the high tree-tops of the forest at Paracoté.

Oporornis formosus (Wilson). KENTUCKY WARBLER.

The Kentucky warbler was observed on several occasions on the Azuero Peninsula, on or near the floor of the forest. Unlike the other North American warblers, this species was represented by solitary

[118]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 374.

individuals apparently not associating either with others of its own kind or individuals of different migrant species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22432	♂	Paracoté	50 Feet	February 17, 1932
22433	♀	Altos Cacao	1500 Feet	February 28, 1932

Setophaga ruticilla (Linnaeus). AMERICAN REDSTART.

Although no specimens were collected, individuals of the American redstart were seen on several occasions in the forests in mixed flocks of migrant North American warblers.

Basileuterus culicivorus godmani Berlepsch. GODMAN WARBLER.

Our specimens from the Azuero Peninsula are indistinguishable from a series of *Basileuterus culicivorus godmani* from Boquete and Volcan de Chiriqui, western Panama.

This mountain species was first found at an altitude of 1500 feet on the forested ridge at Altos Cacao, where 3 specimens were collected. It was not met with again until we reached the higher country near the top of Cerro Viejo, at 3000 feet, where a single specimen was secured.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22438	♂	Altos Cacao	1500 Feet	February 28, 1932
22439	♀	Altos Cacao	1500 Feet	February 29, 1932
22440	♀	Altos Cacao	1500 Feet	February 29, 1932
22441	..	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932

Basileuterus delattrii mesochrysus Sclater. SCLATER WARBLER.

Although no topotypical specimens of *Basileuterus delattrii mesochrysus* have been seen, the single specimen collected is referred to it since specimens collected at various other points along the Pacific slopes of Panama from Chiriqui to Darien have been shown to belong to that subspecies.

The lone specimen taken on a rather scrubby ridge leading up to Cerro Viejo at 2000 feet elevation, represents our entire knowledge of the distribution of this species on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22437	♂	Cerro Viejo Camp	2000 Fet	March 6, 1932

Phaeothlypis fulvicauda veraguensis (Sharpe). VERAGUAN BUFF-RUMPED WARBLER.

From examination of a series of 19 specimens of this species including birds from Boruca and El General, Costa Rica; and Boquete, Azuero Peninsula, Cascajal, Canal Zone, Cerro Azul, Cana, and Obaldia, Panama, the following facts are evident. This series, small as it is, shows a surprisingly gradual and complete intergradation between Costa Rican and eastern Panama birds. In every one of the 10 characters used by Griscom[119] to separate specifically *Phaeothlypis leucopygia* from *Phaeothlypis semicervina*, complete intergradation is shown. The character that changes most abruptly is the marbling of the under parts. The Cana and Obaldia (extreme eastern Panama) specimens show scarcely a trace of this character, but Cerro Azul (40 miles east of Canal Zone) birds are noticeably mardled, and the Canal Zone specimens are heavily marked in this way. In the color of the upper parts and feet, in the buffiness of the under parts and inner portion of the tail, and in the width of the dark terminal tail-band there is gradual and complete intergradation. There is a rather distinct and constant difference between specimens representing the area from Costa Rica to Veraguas and those of the Canal Zone in respect to degree of the buffiness of under parts, sides of head, rump, and inner portion of tail, which might, in a large series, warrant the recognition of *Phaeothlypis fulvicauda toddi* Griscom.[119] However, since the difference merely marks a transition between the characters of *Phaeothlypis fulvicauda semicervina* and *Phaeothlypis leucopygia*, it seems better to give only one name, *veraguensis* to the transitional form.

The 3 Canal Zone specimens examined are fairly uniform in color, yet considerable individual variation is said, by Hellmayr,[120]

[119]Amer. Mus. Novit., No. 280, September 10, 1927, pp. 14-16.
[120]Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part VIII, September 16, 1935, p. 524.

to occur there. The existence of extremely great individual variation in the Canal Zone would not be surprising after having found this to be true in Costa Rica and Veraguas examples. In fact, one Azuero Peninsula bird is more greenish on the back and more grayish on the head than the Obaldia specimen examined. Birds from Cerro Azul, only 40 miles east of Gatum, although intermediate, are definitely referable to *P. f. semicervina*, as has also been pointed out by Todd.[121] On this basis it would be expected that somewhere between Gatun and Cerro Azul a region would be found where the average characters would be exactly intermediate between those of *P. f. veraguensis* and *P. f. semicervina*. Therefore it is not surprising that specimens have been found in the Canal Zone which are closer to eastern Panama birds than to those of western Panama. I am inclined to agree with Hellmayr[120] that such specimens were probably seen by Griscom[122] and Todd[121] and are responsible for the opinion of these authors that *P. semicervina* and *P. veraguensis* are specifically distinct. The writer prefers to consider them as the same species until further field work on the habits and life history of the Canal Zone birds has shown the opposite to be the case.

The Veraguan buff-rumped warbler was encountered twice on our trip. On both occasions a mated pair was found, and in each case the birds were observed low down in the brush by the side of a forest stream. Because of their habitat and habit of wagging the tail up and down, these birds reminded me very much of the Louisiana water-thrush (*Seiurus motacilla*).

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22443	♀	Cerro Viejo, Cavulla	3000 Feet	March 13, 1932
22442	♀	Mariato River Camp	250 Feet	March 18, 1932
22444	♂	Mariato River Camp	250 Feet	March 18, 1932

There are in The American Museum of Natural History 2 specimens, 1 male and 1 female collected by Rex Benson in the interior of the Cape Mala [=Azuero] Peninsula and listed by Griscom[123] under *Basileuterus fulvicauda toddi*.

Cacicus vitellinus Lawrence. LAWRENCE CACIQUE.

No difference could be detected between our specimens and a series of typical *Cacicus vitellinus* from near Panama City.

[120]Zoöl. Ser., Field Mus. Nat. Hist. Vol. XIII, Part VIII, September 16, 1935, p. 524.
[121]Proc. U. S. Nat. Mus., Vol. 74, Art. 7, April 26, 1929, pp. 11-15.
[122]Amer. Mus. Novit., No. 280, September 10, 1927, p. 15.
[123]Amer. Mus. Novit., No. 280, September 10, 1927, p. 14.

A single colony of these interesting birds had established itself in a very tall tree in a small patch of mangrove at Paracoté. The 15 long pendant nests were hung from the lower branches of this tree some 50 feet above the ground.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22445*†	♂	Paracoté	Sea Level	February 14, 1932
22446*	♀	Paracoté	Sea Level	February 14, 1932

*Bill straw color.
†Iris pale blue.

Amblycercus holosericeus centralis Todd. CENTRAL AMERICAN CACIQUE.

Our 4 specimens bear out the characters of *Amblycercus holosericeus centralis* Todd[124] in having wings longer than tail. Peters[125] has shown this character to be inconstant in a very large series of birds from widely distributed points in Central America. However, it is the writer's opinion that the difference in relative length of wing and tail is a good average character which necessitates the recognition of *A. h. centralis*.

The Central American cacique seemed to be fairly common and evenly distributed throughout the forest areas visited.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22447*	♂	Paracoté	Sea Level	February 17, 1932
22448	♂	Mariato River Camp	250 Feet	February 21, 1932
22449	♀	Mariato River Camp	250 Feet	February 21, 1932
22450*	♀	Altos Cacao	1500 Feet	March 3, 1932

*Iris and bill pale straw color, feet bluish gray.

Icterus galbula (Linnaeus). BALTIMORE ORIOLE.

A single male was collected in a small area of mangrove swamp at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22451	♂	Paracoté	Sea Level	April 1, 1932

[124]Proc. Biol. Soc. Washington, Vol. XXXVII, July 8, 1924, pp. 115-116.
[125]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 12. October, 1929, pp. 474-475.

Tanagra laniirostris crassirostris (Sclater). THICK-BILLED EUPHONIA.

Our Azuero Peninsula specimens of this species seem indistinguishable from 4 topotypical examples of *Tanagra laniirostris crassirostris* from Santa Marta, Colombia.

This handsome little euphonia was fairly evenly distributed, although not very common throughout the forested area visited. The male and female taken at Cerro Viejo Camp on March 16 were apparently mated.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22461	♂	Cerro Viejo Camp	2000 Feet	March 16, 1932
22462	♀	Cerro Viejo Camp	2000 Feet	March 16, 1932
22463	♂	Paracoté	50 Feet	March 25, 1932
22464	♂	Paracoté	50 Feet	March 28, 1932
22465	♀	Paracoté	50 Feet	March 29, 1932

Tangara gyrola bangsi (Hellmayr). BANGS GREEN TANAGER.

The single female secured in the mountains of the Azuero Peninsula has been compared with series of typical *Tangara gyrola bangsi* from Boruca, Costa Rica, and Boquete, Chiriqui, and found to differ from them in being of a slightly deeper (less yellowish) green on the back, and of a deeper blue on the rump and breast. It is, however, matched in the bluishness of the breast by Ecuador specimens which Hellmayr[126] was unable to distinguish from typical *T. g. bangsi*, and which Bangs[127] subsequently described as *Tangara gyrola nupera*. A larger series of this species from the isolated mountains of the Azuero Peninsula might show that the birds from that region represent a distinct subspecies. However, nothing further can be done with a single female specimen than to refer it to *T. g. bangsi*, which form the Azuero Peninsula birds geographically most closely approach.

The single specimen taken at 3000 feet on Cerro Viejo is the only individual of this subtropical zone species recorded.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22468	♀	Cerro Viejo, Cavulla	3000 Feet	March 14, 1932

[126]Proc. Zoöl. Soc. London, 1911, Part IV, December 15, 1911, p. 1106.
[127]Proc. New England Zoöl. Club, Vol. VI, December 21, 1917, p. 76.

Tangara larvata franciscae (Sclater). FRANCISCA TANAGER.

An adult female and an immature male of this gaudy little tanager collected at Paracoté are all the records obtained by us for its occurence on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22466	♀	Paracoté	50 Feet	February 9, 1932
22467	♂ im.	Paracoté	Sea Level	March 27, 1932

Thraupis episcopus diaconus (Lesson). NORTHERN BLUE TANAGER.

It seems to the writer that the Colombian and Central American blue tanagers are subspecies of *Thraupis episcopus*.

With a series of 100 specimens of this species for examination from localities ranging from southern Mexico to Colombia, it is obvious, as has also been noted by Griscom,[128] that Panama birds are intermediate between *Thraupis episcopus cana* and *Thraupis episcopus diaconus*. Griscom[129] has referred specimens from extreme eastern Panama to *T. e. cana*, and those from "at least the Canal Zone westward" to *T. e. diaconus*. With the first of these allocations the writer cannot agree. Compared with 15 specimens of *T. e. cana* from Santa Marta, Jiminez, Cali and Atuncela, Colombia, and 22 specimens of *T. e. diaconus* from Nicaragua, Honduras, Salvador, and Guatemala, the 7 available specimens from Cana, Permé, and Obaldia, eastern Panama, seem definitely nearer the latter. It must be admitted, however, that no topotypical specimens of *T. e. cana* have been available to me for comparison, which may account for the discrepency of opinions. Specimens from the Canal Zone westward in Panama, including the present Azuero Peninsula birds, are definitely the darker northern form *T. e. diaconus*, and if any Panama birds are referable to *T. e. cana* it seems that it should be those from the Pearl Islands which have been named *T. e. dilucida* by Thayer and Bangs.[130] The series of 20 specimens that the writer has examined from the Pearl Islands seems almost exactly intermediate between typical *T. c. cana* and *T. e. diaconus*, but possible slightly favoring the later race. To my mind the specimens from the entire

[128]Bull. Amer. Mus. Nat. Hist., Vol. LXIV, May 7, 1932, p. 376.
[129]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 8, April, 1929, p. 189.
[130]Bull. Mus. Comp. Zoöl., Vol. XLVI, No. 8, September, 1905, pp. 157-158.

mainland of Panama are more typical of *T. e. diaconus* than are those from the Pearl Islands. In view of its intermediate position and the slightness of its difference from either *T. e. cana* or *T. e. diaconus* it does not seem to the writer advisable to recognize *T. e. dilucida* as a distinct subspecies. If, however, this intermediate form be ever considered separable, then, as pointed out by Griscom[131] the birds of the mainland of Panama must be referred here.

The northern blue tanager was an abundant bird on the cocoanut plantation at Paracoté, frequenting the cocoanut palms and shade trees about the houses and the edges of the second-growth forest. Away from the plantation, however, not a single individual was found.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22454	♂	Paracoté	50 Feet	February 5, 1932
22455	♀	Paracoté	Sea Level	February 5, 1932
22456	♂	Paracoté	50 Feet	February 11, 1932
22457	♂	Paracoté	50 Feet	February 12, 1932

Thraupis palmarum atripennis Todd. BLACK-WINGED PALM TANAGER.

The 2 Azuero Peninsula specimens of this species were matched by specimens of typical *Thraupis palmarum atripennis* from Costa Rica.

The black-winged palm tanager was not observed on the Azuero Peninsula on any other occasion than those of the capture of 2 specimens in the lowland forest at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22452	♂	Paracoté	50 Feet	February 8, 1932
22453	♀	Paracoté	50 Feet	February 12, 1932

Ramphocelus dimidiatus isthmicus Ridgway. PANAMA CRIMSON-BACKED TANAGER.

Comparison of larger series of typical *Ramphocelus dimidiatus dimidiatus* from Colombia, *R. d. isthmicus* from the Canal Zone,

[131]Bull. Amer. Mus. Nat. Hist., Vol. LXIV, May 7, 1932, p. 376.

R. d. pallidirostris [=*albirostris*][132] from western Chiriqui, and *R. d. limatus* from the Pearl Islands show the 2 Azuero Peninsula specimens to be typical *R. d. isthmicus*, thus extending the range of this subspecies from the Canal Zone westward along the Pacific coast of Panama about half way to Divala, the type locality of *R. d. pallidirostris*. Strangely enough the Azuero Peninsula birds do not seem to show any tendency toward intergradation between *R. d. isthmicus* and *R. d. pallidirostris*.

The Panama crimson-backed tanager, called "sangre del toro" by the natives, was a very common bird at the forest margin, in the shade trees and in the cultivated areas about the plantation, where brilliant flashes of red caused by the flight of these birds from one tree to another were a familiar sight.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22473	♀	Paracoté	50 Feet	February 8, 1932
22474	♂ im.	Paracoté	50 Feet	February 14, 1932

Piranga rubra rubra (Linnaeus). SUMMER TANAGER.

The single female specimen collected in the forest along the Mariato River was all that was seen of this North American migrant on the Azuero Peninsula.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22472	♀	Mariato River Camp	250 Feet	February 24, 1932

Habia rubica aurantiicapilla, subsp. nov. ORANGE-CROWNED ANT TANAGER

Subspecific Characters.—Similar to *Habia rubica vinacea* from the Canal Zone and eastern Panama, but larger and paler; the male slightly paler and brighter (more reddish) above and below; the female much paler and more yellowish olive green above, crown patch more orange, (less yellowish), under parts paler and more brownish and yellowish.

[132]Hellmayr, Zoöl. Ser., Field Mus. Nat. Hist., Vol. XIII, Part 9, October 6, 1936, p. 256.

Measurements.—*Adult male* (6 specimens from western Costa Rica): wing, 90.5-94.5 (average, 93) mm.; tail, 78.5-83 (81.4); exposed culmen, 16.5-18.5 (17.6); tarsus, 23.5-25 (24.3). *Adult female* (9 specimens from western Panama and western Costa Rica): wing, 83-89.5 (average, 86) mm.; tail, 69.5-79 (75.7); exposed culmen, 16.5-18 (17.4); tarsus, 23-24.5 (23.8).

Type.—Adult female, No. 22460, Cleveland Museum of Natural History; Cerro Viejo, altitude 3000 feet, between the headwaters of the Negro and Mariato Rivers, 18 miles east of Montijo Bay, Veraguas, Panama, March 11, 1932; John W. Aldrich, original number 1942.

Geographic Distribution.—Pacific slopes of western Panama to the Pacific slopes of western Costa Rica (Azuero Peninsula, Panama, to Nicoya Peninsula, Costa Rica).

Remarks.—As Griscom[133] has pointed out, the birds of this species from eastern Panama (Cana) are inseparable from typical *Habia rubica vinacea* from the Canal Zone. It is rather strange, however, that birds from western Panama and western Costa Rica have been considered by so many authors the same as the Canal Zone form, from which they differ so markedly, particularly in the case of the females. Fifteen specimens of *Habia rubica aurantiicapilla* from the Azuero Peninsula and western Costa Rica are separable from 9 specimens of *H. r. vinacea* from the Canal Zone and eastern Panama, chiefly on the basis of larger size of the males and the paler coloration and orange instead of yellow crown patch, as well as the larger size of the females. The under parts of the females of *H. r. aurantiicapilla* are subject to great individual variation in hue, varying from a yellowish olive green to a brownish olive green, this possibly due to age. Despite this individual difference in color, however, the under parts of *H. r. aurantiicapilla* are distinctly and constantly paler than the equally variable under parts of Canal Zone and eastern Panama examples of *H. r. vinacea*. A female has been chosen for the type of *H. r. aurantiicapilla* since the subspecific characters are more pronounced in this sex than in the male.

On the Azuero Peninsula the orange-crowned ant tanager was apparently confined to the forests of the higher altitudes, as it was

[133]Bull. Mus. Comp. Zoöl., Vol. LXIX, No. 8, April, 1929, p. 189.

not encountered below 2000 feet. Even at the higher elevations, however, it was not a common bird, the 3 females collected being the only individuals seen.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22458	♀	Cerro Viejo, Camp	2000 Feet	March 6, 1932
22459	♀	Cerro Viejo, Camp	2000 Feet	March 7, 1932
22460	♀	Cerro Viejo, Cavulla	3000 Feet	March 11, 1932

Eucometis penicillata stictothorax (Berlepsch). STREAKED-CHESTED TANAGER.

Our Azuero Peninsula specimens, compared with a large series of *Eucometis penicillata stictothorax*, proved to be typical.

The streak-chested tanager was found to occur, but rather uncommonly, in the forests at Paracoté and along the Mariato River.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22469	♀	Mariato River Camp	250 Feet	February 26, 1932
22470	♂	Paracoté	50 Feet	March 25, 1932
22471	♀	Paracoté	50 Feet	March 29, 1932

Oryzoborus funereus Sclater. LESSER RICE GROSBEAK.

The lesser rice grosbeak occurred together with the Hicks seedeater (*Sporophila aurita aurita*) and northern grassquit (*Volatinia jacarini atronitens*) on the grassy lowland llanos and open grassy patches among the cocoanut trees at Paracoté, but in smaller numbers than either of these 2 other species.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22485	♂	Paracoté	Sea Level	February 13, 1932
22486	♀	Paracoté	Sea Level	March 23, 1932

Sporophila aurita aurita (Bonaparte). HICKS SEEDEATER.

The Hicks seedeater was a very common species in open grassy areas on the cocoanut plantation and on the small llanos at Paracoté where it moved in small flocks, associating with the northern

grassquit (*Volatinia jacarini atronitens*) and an occasional lesser rice grosbeak (*Oryzoborus funereus*.) These tiny finches would sway up and down on the slender grass stalks while feeding on the seeds in the heads of these cereals.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22491	♂	Paracoté	50 Feet	February 7, 1932
22492	♂	Paracoté	50 Feet	February 9, 1932
22493	♀	Paracoté	50 Feet	February 13, 1932
22494	♀	Paracoté	50 Feet	February 14, 1932
22495	♂ im.	Paracoté	50 Feet	March 25, 1932

Volatinia jacarini atronitens Todd. NORTHERN GRASSQUIT.

The single fully adult male taken on the Azuero Peninsula is more purely black (less purplish) than 5 adult males from southern Mexico, including 2 topotypes of *Volatinia jacarini atronitens*. It, however, has the under wing-coverts and axillars entirely black, the character which was used by Todd[134] to distinguish *V. j. atronitens* from *Volatinia jacarini splendens*. The single adult female from the Azuero Peninsula is darker throughout than 4 adult females from southern Mexico. A larger series from the Azuero Peninsula might prove to be separable.

The grassquit was a common species in the lowlands of the Azuero Peninsula, occurring in little groups of a dozen or so birds, frequently associating with the Hicks seedeater (*Sporophila aurita aurita*) in grassy areas about the plantation and the small llanos at Paracoté.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22487	♂	Paracoté	Sea Level	March 23, 1932
22488	♂ im.	Paracoté	Sea Level	March 23, 1932
22489	♂ im.	Paracoté	Sea Level	March 23, 1932
22490	♀	Paracoté	Sea Level	March 23, 1932

Saltator maximus intermedius (Lawrence). PANAMA BUFF-THROATED SALTATOR.

Compared with a large series of all the southern Central American races of this species our Azuero Peninsula birds prove to be referable to *Saltator maximus intermedius*.

[134]Proc. Biol. Soc. Washington, Vol. XXXIII, December 30, 1920, p. 72.

The Panama buff-throated saltator was a very common bird in the second growth forest edges at Paracoté. It was also found at Mariato River camp and at Altos Cacao in second growth areas which had formerly been cut off for cultivation.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22476	♂	Paracoté	50 Feet	February 5, 1932
22477	..	Paracoté	50 Feet	February 8, 1932
22478	♀	Paracoté	50 Feet	February 10, 1932
22479	♂	Paracoté	50 Feet	February 17, 1932
22484	♂	Paracoté	50 Feet	March 29, 1932
22480	♀	Mariato River Camp	250 Feet	February 21, 1932
22481	♂	Mariato River Camp	250 Feet	February 23, 1932
22482	♀	Altos Cacao	1500 Feet	February 28, 1932
22483	♀	Altos Cacao	1500 Feet	March 3, 1932

Saltator striatipictus isthmicus Sclater. PANAMA STREAKED SALTATOR.

Our single Azuero Peninsula specimen of this species has been compared with good series of *Saltator striatipictus isthmicus*, *Saltator striatipictus furax*, and *Saltator striatipictus speratus*, including the types of the last 2 forms, and found to be fairly typical of *Saltator striatipictus isthmicus*.

Our knowledge of the occurrence of the Panama streaked saltator on the Azuero Peninsula is confined to the record of the single specimen captured at Altos Cacao in a clearing in the forest made some years previous for purposes of cultivation, but which had grown up to a dense tangle of brush.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22475	♂	Altos Cacao	1500 Feet	March 3, 1932

Arremonops striaticeps striaticeps Lafresnaye. LAFRESNAYE SPARROW.

Our Azuero Peninsula specimens, when compared with large series of both *Arremonops striaticeps richmondi* and *Arremonops striaticeps striaticeps*, prove to be nearer the latter subspecies in size and in

shade of gray on the head. This discovery extends the known range of the *A. s. striaticeps* some 120 miles westward on the Pacific coast of Panama from the Canal Zone, which was previously considered the approximate dividing line between the ranges of *A. s. striaticeps* and *A. s. richmondi*.

The Lafresnaye sparrow was a common species in the more open brushy country in the vicinity of the plantation at Paracoté and was fairly common at the border line between forest and savannah on the crests of the mountain ridges leading up to Cerro Viejo in the vicinity of 3000 feet elevation. As we stood on the summit of Cerro Viejo, its pleasing song could be heard repeatedly coming from the spurs of stunted forest that reach up along the draws on the mountain side from the vast areas of verdant unbroken rain forest in the valleys below.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22502	♀	Cerro Viejo, Cavulla	3000 Feet	March 11, 1932
22503	♂	Cerro Viejo, Cavulla	3000 Feet	March 12, 1932
22500	♂	Paracoté	Sea Level	February 13, 1932
22501	♂	Paracoté	Sea Level	February 13, 1932
22504	♂	Paracoté	Sea Level	March 23, 1932
22505	♂	Paracoté	Sea Level	March 27, 1932
22506	♂	Paracoté	Sea Level	April 2, 1932
22507	♂	Paracoté	Sea Level	April 2, 1932
22508	♂	Paracoté	Sea Level	April 2, 1932

Arremon aurantiirostris aurantiirostris Lafresnaye.
ORANGE-BILLED SPARROW.

One of the Azuero Peninsula specimens of this species is paler and more greenish on the back and has the gray areas of the head paler than any individual of a series of 9 typical specimens from the Canal Zone. The other Azuero Peninsula specimen, however, seems to agree fairly well with the Canal Zone series.

The 2 individuals collected at 2 different forest camps were all that were seen of this handsome sparrow.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22509	♂	Mariato River Camp	250 Feet	February 25, 1932
22510*	..	Altos Cacao	1500 Feet	March 3, 1932

*Bill orange.

Atlapetes gutturalis azuerensis, subsp. nov. AZUERO YELLOW-THROATED SPARROW.

Subspecific Characters.—Similar to *Atlapetes gutturalis fuscipygius* of Nicaragua and Honduras, but slightly more brownish on back and flanks; and white crown stripe broader.

Measurements.—Adult male (4 specimens from the Azuero Peninsula): wing, 71-77.5 (average, 74.9) mm.; tail 74.5-80 (78); exposed culmen, 13-14.5 (13.9); tarsus, 26.5-27.5 (27.1).

Type.—Adult male, No. 22496, Cleveland Museum of Natural History; Cerro Viejo, elevation 3000 feet, between headwaters of the Negro and Mariato Rivers, 18 miles east of Montijo Bay, Province of Veraguas, Panama, March 11, 1932; B. P. Bole, Jr. and John W. Aldrich, original number, 1938.

Geographic Distribution.—Probably confined to the subtropical zone of the isolated mountains of the Azuero Peninsula.

Remarks.—Atlapetes gutturalis azuerensis is extremely different in color from the 2 geographically closest races, *A. g. brunnescens*, of western Chiriqui and *A. g. coloratus* of the main cordillera of Veraguas. The Azuero Peninsula form is closer to *A. g. brunnescens* than to *A. g. coloratus*, but is much more brownish on the back, rump, wings, flanks, and under tail coverts, has a narrower white crown stripe and slightly paler yellow throat-patch than the former subspecies. *A. g. azuerensis* differs from *A. g. coloratus*, *A. g. parvirostris* and *A. g. gutturalis* mainly in having brown, rather than gray, back, flanks, and under tail-coverts. Its size is apparently the same as that of other Central American subspecies.

The remarkable difference between *A. g. azuerensis* and its geographically nearest relative, *A. g. coloratus* of the main cordillera in Veraguas and eastern Chiriqui, is hard to explain. Although the writer has seen no specimens of *A. g. coloratus*, it is apparent from the description of that form that the birds of the mountains of the Azuero Peninsula are about as dissimilar as they are unlike any other known race of this species. The bird that most nearly approximates the above-mentioned new subspecies is *A. g. fuscipygius* of

Nicaragua and Honduras, which is also a bird with brown back, flanks, and under tail-coverts. Oddly enough, however, the ranges of these 2 forms are separated by the ranges of at least 3 other well-marked and very different subspecies, *A. g. coloratus*, *A. g. brunnescens* and *A. g. parvirostris*. This characteristic of discontinuous geographic variation seems well developed in *Atlapetes gutturalis* and has been commented upon by Dwight and Griscom.[135] Cases like this afford perplexing problems with respect to the relationships of the various forms. Obviously there is no progressive intergradation existing here at the present time, nor is there any certainty that it ever existed. As is true in the case of geographic races of many other species of birds, *Atlapetes gutturalis azuerensis* and *A. g. coloratus* intergrade through forms which are not geographically intervening and which indeed may even be the result of parallel evolution. Nevertheless, an individual form similar enough to two other forms to be considered morphologically intermediate between the two, whether geographically intermediate or not, indicates rather strongly that many of the same hereditary factors are present in all these forms. This would seem to indicate a not too far distant common ancestor. For the present at least, the writer will continue to accept as best indicating true genetic relationship the criterion elucidated by Oberholser,[136] by which forms are recognized as subspecifically related if they intergrade, even though the intergrading forms are not geographically intermediate.

The Azuero yellow-throated sparrow occurred in small flocks among the dwarfed trees of the forest margin in two different places near our camp at Cavulla.

Specimens Collected

C. M. N. H. Number	*Sex*	*Locality*	*Elevation*	*Date*
22496	♂	Cerro Viejo, Cavulla	3000 Feet	March 11, 1932
22497	♂	Cerro Viejo, Cavulla	3000 Feet	March 11, 1932
22498	♂	Cerro Viejo, Cavulla	3000 Feet	March 12, 1932
22499	♂	Cerro Viejo, Cavulla	3000 Feet	March 12, 1932

[135]Amer. Mus. Novit., No. 16, September 9, 1921, p. 1.
[136]Science, N. S., Vol. XLVIII, August 16, 1918, pp. 165-167.

ANNOTATED LIST OF MAMMALS OF THE MARIATO RIVER DISTRICT OF THE AZUERO PENINSULA

By B. P. Bole, Jr.

Two months of intensive field endeavor by the junior author, assisted at times by Mr. Aldrich and Mr. Davies, resulted in a collection of one hundred forty-one preserved mammal specimens, all originally deposited in The Cleveland Museum of Natural History. About fifty others were not saved, having been mutilated almost beyond recognition in the field. Practically all of these discarded individuals were of the two commonest forms to be found on the Mariato River drainage—*Zygodontomys cherriei ventriosus* and *Sigmodon hispidus borucae*, species which comprise the bulk of the existing collection. Besides these two, specimens are on hand of twenty other forms, and photographic evidence of one more, the deer of the region. As in the case of the birds, the Cleveland Museum's collections were unable to supply more than a meagre fraction of the requisite comparative material, and I borrowed from three sources: the United States Biological Survey, the Museum of Comparative Zoölogy at Harvard, and the Field Museum of Natural History. To Major E. A. Goldman and Dr. H. H. T. Jackson of the Biological Survey I am greatly indebted for the loan of specimens and invaluable critical comments in the regard to the manuscript of this paper. To Dr. Thomas Barbour and Dr. Glover M. Allen of the Museum of Comparative Zoölogy I am indebted not only for the loan of specimens but also for the priceless opportunity of working on my collection in their laboratories, with their extensive material at my disposal. I am further indebted to Dr. Allen for assistance and advice given during the course of certain identifications. To Dr. S. C. Simms of the Field Museum I owe thanks for the loan of their specimens of the spiny pocket rat, *Liomys adspersus*.

The mammal population of the Mariato region is as remarkable for what it does not contain as for what it does. As in most isolated areas, the species present seem to be few in number and the forms tend to differ from those of nearby faunae. Many genera character-

istics of other parts of Panama are missing here; among the monkeys, *Saimiri* and *Leontocebus; Microsciurus* among the squirrels; the tapir is unknown; there are no brockets, no great anteaters, and a deficient representation of many genera of smaller mammals. Had our trip been of longer duration this deficiency list might well have been reduced but considerable effort was made to enlarge our lists from the much wider experience of Mr. Davies, Mr. Richards, our head porter Ignacio Alvarado, and others. Doubtless a number of arboreal forms eluded us as we were unequipped with live traps, while the short time we had at any one camp precluded any detailed study of the nocturnal tree-living species. It seems likely that there is an important bat fauna that would have been obtained, had we known where to find their caves or other roosting places. In view of all this, this report on mammals is to be regarded as provisional and for one small area only, the Mariato River drainage basin. Some of the species that we did not find may well be there; others are undoubtedly absent from the region, for various reasons enumerated elsewhere in this joint report.

Trapping conditions, as in most tropical regions, we found atrocious. Warm, humid nights, legions of ants, and a general scarcity of mammal populations all militated against the field collector. These discomforts experienced from insect pests and the protective measures they necessitated diminished our efficiency and energy in the field. Our rate of travel was not conducive to thorough trapping of any area but there was little incentive to stay at stations where two or three mammals a day would be yielded from a trapline two or three miles in length and numbering two or three hundred sets. The primary reason for the smallness of our yield—141 specimens in two and a half months was that the mammals were not there.

The climate of the region is no doubt partially responsible for this. For nine months of the year field and forest and mountainside are flooded with a downpour that even at Paracoté on the coastal plain amounts to over 130 inches annually. For the rest of the year, searing drought is the rule on the coastal plain; many of the trees lose their leaves; the forest floor becomes hard and unfriable, and nearly all ground-cover vegetation vanishes. No fallen logs survive in the forest away from soggy ravine-bottoms and flood-plains;

termites take care of them. In short, most of the woodland of the Mariato region is nearly devoid of cover for small animals. The obvious places for large populations are the flood plain woods and the crown of all the forests including the mangrove jungles. The last of these areas was not investigated by us at all with regard to mammals. As other writers[137] have pointed out, however, the dry season inhabitants of wet woodlands in Panama may sometimes be the wet season inhabitants of the uplands or vice versa, as the case may be; so the meagre list I obtained from ravine bottoms may have been of species generally distributed through the woods in June, when, according to our hosts and guides, tabanid flies render Mariato's woods all but impenetrable.

Not only, therefore, is the semi-arid savannah belt at the head of the peninsula, a type of habitat found by other collectors[138] very deficient in mammal life, a barrier for many species, but so also is the forest fringing the base of the Azuero ranges. Perhaps this double barrier—accentuated if the peninsula has recently been an island—accounts for the mammalogical desolation of the highlands—the upper tropical zone, to the lower edge of which we penetrated. Not one species characteristic of this zone in other parts of Panama did we secure. Perhaps they occur at a higher level than we attained and it is our hope to be able to return to this higher country at some later date.

Besides the species listed on the following pages, we obtained records of one sort or another of a few species the genera of which could not be determined from the descriptions given. Wherever there is no question concerning the genus to which the record should be referred, it is included under the annotated list.

A native laborer was sure that he had seen an oppossum of a species different from the three here listed, but could give no salient features of it.

Mr. Richards reported that a dog he once owned had killed a sloth on the port road as the ungainly creature was trying to creep across it. He was quite unable to remember the anatomy of its feet.

[137]Enders, Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, pp. 390, 451.
[138]Bangs, Bull. Mus. Comp. Zoöl., Vol. XLVI, No. 12, January, 1906, p. 212.

Vampire bats, alone among the Chiroptera, can figure in this report, as evidences of their presence were noted on a few occasions. At Paracoté several of our horses were bitten by these creatures before the beginning of our pack trip. A trapped *Proechimys* was also the victim of vampire attack at this station. The natives are thoroughly acquainted with them, but did not seem to fear them greatly, and our porters were not very determined about keeping themselves covered at night in the course of our pack-trip.

At the Mariato Rubber Camp, several bats were flying close to the ground around our camp, with rather slow, hesitating flight. Our men suspected that these were vampires. They rarely came within range of the Coleman lantern's rays and may well have been of a harmless species in quest, perhaps, of insects. I flushed one from the ground, which may be evidence of sorts, as the animal seemed to "spring" into the air.

Bats were an uncommonly inconspicuous part of the Mariato fauna. In all, I saw not over two dozen in the entire course of the expedition. At Paracoté, where I spent considerable time outdoors in the evenings, I saw just one bat, perhaps the same individual, in the same place on several successive evenings. It was a very small animal of *Myotis*-like flight, perhaps *Myotis nigricans*, which should occur there.[139] At the Mariato Rubber Camp a few other bats, larger than the alleged "vampires," were flying to and fro overhead under the leafy crown of the forest. We shot at them but obtained no specimens. We dared not shoot at the low-flying "vampires" for fear of collecting samples of mankind or his works. It seems a possibility that some of the bites suffered by our horses may have been the work of *Diphylla centralis*, but as no specimens were collected we could not determine which species was present. So far as is known at present, *Diphylla* is always much rarer than *Desmodus* in Panama[140].

Didelphis marsupialis *ssp.* GRAY OPOSSUM.

One evening, when we were encamped on the top of the sharp wooded ridge separating the deep valleys of the Negro and Mariato rivers, a muffled shuffling in dry leaves attracted our attention to

For an account of the bats of the Panama region, see
[139]Goldman, Smithsonian Misc. Coll. Vol. 69, No. 5, 1920, pp. 172-222, and Allen, G. M. Jour. Mamm., Vol. 16, No. 3, August, 1935, pp. 226-228.
[140]Goldman, loc. cit., p 208

a patch of brush near our tent. Shortly an opposum, that might as well have appeared from an Ohio hedgerow, stepped into view and nosed about the pathway in front of the tent, dimly illuminated by the Coleman lantern within. It was quite active and amazingly tame. I turned a flashlight full on it at a distance of fifteen or twenty feet, to its great unconcern. It apparently captured several insects that were attracted to the beam of light, and made one abortive rush at a large insect that landed at the edge of the brushy patch. At this point, I remembered that I was observing a species unlisted in our collection, and returned to the tent for my gun. My opposum had assumed its original status, however, when I returned—a muffled shuffling in the leaves under the blackness of the Panamanian night.

Splay-footed tracks of this species were seen subsequently at sea level, in the dust of the "port" road leading from the Paracoté settlement to the mangrove-bordered estero that served as a harbor. No specimens were taken, but the form occurring in the district was probably *etensis*, the one that ranges from one end of Panama to the other along the main cordillera to the north.

Metachirops opossum fuscogriseus (Allen). Allen's Opossum; Zorro.

These small active opossums were, to judge from the tracks seen in the roadways of the Paracoté plantation, very abundant in that region. The three specimens taken were all caught in steel traps placed in runways among weeds and small brush.

Several writers have commented on the aggressive disposition of this species, comments well merited, to judge from the behavior of my specimens. Two were weasel-like in their eagerness to bite. They made no sound until I approached within reach, whereupon their slashing bites were accompanied by hisses and shrill, growling snarls. One specimen was killed in the trap by native plantation laborers before I got to that part of my trapline; they strongly and commendably disapproved of the brutality of steel traps.

The stomach contents of one male animal consisted of insects of various sorts, carapaces of crabs, a few partly broken seeds, and the remains of a two-thirds grown *Sigmodon*. This item had apparently been eaten in its entirety, as fragments of skin, hair, cranial elements, caudal vertebrae, and three feet were noticed. It appeared to have been the most recent meal of the opossum.

A female, taken February 18, 1932, at sea level contained five embryos about 10 mm. in length. These were active and stayed alive for twenty-four hours after the skin was made up, wrapped in a piece of moist paper. They were only loosely attached to the teats of the mother.

The altitudinal range of this species is extensive, as one specimen was taken at Cavulla, well over 3000 feet in elevation. In that region of timbered hollows and llano-topped ridges, little game trails pass from point-of-woods to point-of-woods over the intervening grassy saddles for distances of only a few hundred feet or half a mile. In one of these paths the *Metachirops* was taken.

Specimens: Paracoté, 2; Cavulla, 1.

Marmosa mexicana mexicana Merriam. MEXICAN MARMOSA.

According to the specimens listed on the distribution map given by Tate,[141] the occurrence of this marmosa at Mariato extends the known range of the form southwards about a hundred miles. Only three specimens were taken, of which only two were savable. Both of these were found alive in rat traps set beside rotting logs in a dank ravine-bottom forest. Both specimens had been attacked by ants, the entire terminal two-thirds of the tail of one had been removed, and the animals were covered with wounds. Despite this, they were still willing to fight when removed from the traps. Live-trapping is certainly a more humane and profitable way of obtaining specimens of this species.

Apparently marmosas are not abundant at Mariato, as the natives seemed unfamiliar with them, while the other two opossums here listed were well known.

[141]Tate, Bull. Amer. Mus. Nat. Hist., Vol. LXVI, Art 1, August 10, 1933, p. 129.

Measurements:

C. M. N. H. No.	Length	Tail	Hindfoot	Greatest Length of Skull	Zygomatic Breadth	Palatal Length	Least Width Across Pterygoid	Greatest Breadth of Palate across outer borders of M.	Greatest Length of Nasals	Postorbital Constriction	Greatest Breadth of Brain Case	Greatest Length of Mandibl
1141♂			21	34.1	18.6	18.9	4.0	11.0	15.5	6.2	13.1	25.2
1150♀	267	146	20			18.7	3.8	11.5	15.2	6.1		24.5

Alouatta palliata trabeata Lawrence. HERRERA HOWLER MONKEY.

Howler monkeys are more often heard than seen at Mariato. Their deep-throated voices once scared a German visitor at Paracoté into refusing to go into the woods without armed assistance, on the grounds that lions abounded in the vicinity. Great was his amazement when monkeys proved to be the source of his terror! Our own astonishment was no less great when we first heard them, fortified as we were with considerable howler lore.

The monkeys were both heard and seen regularly at all our camps except the highest, the Cavulla stations, where they evidently found an uncongenial environment in the cold, fog-soaked, mossy woods. Their serenades were as often heard at night as at day. Like the voices of the huge toads that sang by the Mariato River in the evenings, howler howlings decrease in volume as one approaches the source; an animal only a few feet away seems to have nothing uncommonly big about his voice, except as it is compared to the bird-like notes of the white-faced species.

Unlike the whitefaces, I found a troop of these monkeys very menacing when I shot one of their number. The adults of the troop came down to within ten feet of me, hair on end, teeth bared. At each retreat by me they would make short explosive charges, and

gave ground very slowly, roaring and snarling. When I left my victim to see what they would do, three of the largest descended at once to the fallen animal's side, from which I could not drive them even by advancing. I finally discharged my gun in the air which drove them back overhead to a height of about 20 feet. I did not care to shoot any more as I already had other animals to be carried and skinned, and it was getting late. They followed me up the side of the nearly vertical ridge and only left when the timber degenerated into heavy brush farther along the ridge-top trail.

While the larger members of the troop were "hazing" me near the ground, several others, from an elevation of 30 feet or more made what I can only interpret as a deliberate attempt to defecate on me. Their indeterminate aim was the only factor that leads to any hesitation on my part in making this interpretation of their behavior.

Both of the specimens we obtained were badly infested in the neck and breasts with the larvae of some species of *Cuterebra*, pests which subsequently caused a member of our expedition considerable annoyment. This seems to be a general observation on the subject of howlers, witness the comments of Goldman.[142] Perhaps it is a reason for the fact that this species is looked upon with revulsion by most Mariato natives who rarely, if ever, eat it. For an exhaustive account of the habits of the related form, *aequatorialis* from the main cordillera of Panama, see Carpenter.[143]

Species Number	Sex	Total Length	Tail	Hindfoot	Greatest Length of Skull (Exclusive of Incisors)	Basilar Length	Palatal Length (From most anterior point on posterior border)	Length of Rostrum (From right orbital border)	Zygomatic Width	Width of Brain Case	Greatest Width—Upper Molar Series	Maxillary Toothrow	Lower Cheek Teeth	Width of Pm. 1
1172 Adult	♂	1167	647	150	112.0	91.8	39.3	34.5	83.5	53.0	8.6	43.4	46.4	6.7
1185 Adult	♀	1111	593	146	100.5	82.7	35.3	29.6	72.3	48.7	8.6	39.9	44.5	6.8

[142]Smithsonian Misc Coll , Vol 69, No 5, 1920, p. 229
[143]Comp Psych Mon., Vol 10, No 2, 1934, pp 1-168

Cebus capucinus imitator Thomas. PANAMA WHITE-FACED MONKEY.

White-faced monkeys—los monos cariblancos—are undoubtedly the most frequently seen mammal of the Mariato woodlands. This may seem very curious to northern naturalists, but in a land where there is no chipmunk, and where rabbits and squirrels are relatively uncommon and secretive, the field of diurnal species is much reduced.

Capuchins travel in large bands and are noisy, alert, and full of curiosity. I have little in my notes about their habits that has not already been stated by Enders[144] about the capuchins of Barro Colorado. In connection with their stick-breaking habit, however, it seems that this is deliberately purposeful, as I watched one young monkey take a short fall when he trusted his weight to a dead branchlet that broke off half-way to its end under him. He at once climbed back to the spot and broke off the remainder of the branch. It is apparently "road repair," perhaps grown into a persistent habit with the passing of time. Occasionally these monkeys went to seemingly excessive effort to remove dead branches. I saw one pull at a stout branch, first with his forefeet, then with his forefeet and hindfeet, his only support being his tail. The branch broke off, and he spun halfway around his support on that member.

One female monkey that I shot had a quarter-grown young clinging to her. As the mother fell, he quickly left her, sitting on the branch crying pitifully with his hands over both eyes! The troop immediately stopped its flight, and one adult rushed down, seized the young one and carried it off to safety.

It was frequently noticed that a troop of white-faces caused the withdrawal of most of the bird life from its immediate vicinity, and those birds that dared stay close were invariably in high alarm and rage, particularly the chachalacas (*Ortalis*). At Cavulla I watched a flock of jays (*Cyanocorax*) annoying a solitary pair of monkeys by making dashes at them as they fled through the trees from me. Several writers have mentioned the fondness of capuchins for eggs and young birds, and their unpopularity in avian circles is no doubt stimulated by that. Those that I saw feeding were invari-

[144]Bull Mus Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 445.

bly eating either fruits, flower-petals, or insects. They seemed particularly fond of the blossoms of a liana with showy pink flowers that grew abundantly on the ridges about Altos Cacao.

These monkeys are considered rather poor food by the natives and are infrequently killed for this purpose. We saw troops of them at all elevations visited, from sea level to 3000 feet.

Specimens obtained: Total number 8, as follows: Paracoté, 1; Mariato Rubber Camp, 1; Altos Cacao, 4; Cerro Viejo, 2.

C. M. N. H. No.	Sex	Total Length	Tail	Hindfoot	Greatest Length of Skull (Exclusive of incisors)	Basilar Length	Palatal Length (From most anterior part of posterior border)	Length of Rostrum (From Lacrimal border of orbit)	Upper Maxillary Toothrow (crowns)	Zygomatic Breadth	Lower Maxillary Toothrow (Alveolar Borders)	Greatest Length of Lower Jaw (Coronoid to Angular Process)	Greatest Width of M_3 (Upper jaw, crown)	Greatest Width of Pm_3 (Upper jaw, crown)
1183 Adult	♂	922	523	143	102.1	67.7	33.4	27.0	29.5	67.5	32.6	42.6	5.8	6.6
1186 Subadult	♂	855	439	137	97.7	64.2	32.4	23.7	28.4	62.7	31.6	32.0	6.0	6.7
1189 Adult	♂	877	505	131	98.5	67.0	33.7	25.8	27.2	65.3	31.3	36.3	5.7	6.1
1187 M_3 emerging	♀	841	445	127	94.1	58.2	66.9	21.3		56.3		30.3	5.9	6.6
1194 Adult	♀	871	490	127	91.0	61.6	31.1	22.7	27.6	60.0	30.3	31.7	5.8	6.2
1195 Adult	♀	904	497	130	98.5	62.7	30.8	24.9	27.4	61.2	30.1	34.3	5.7	6.2

Ateles azuerensis sp. nov. AZUERO SPIDER MONKEY.

Type Locality.—Altos Negritos, 10 miles east of Montijo Bay (part of the spur forming south drainage divide of Rio Negro, altitude 1500 feet), Mariato Suay Lands, Veraguas Province, Panama.

Type.—Specimen No. 1235, adult female, Cleveland Museum of Natural History; collected by Ignacio Alvarado, March 23, 1932. Field number, B-A 115.

Geographic Distribution.—Azuero Peninsula of Panama, probably on both slopes of the mountains in deeper forests, but known only from the western (Veraguas) side, from the vicinity of Ponuga southwards.

General Characters.—A small form with contrasting colors and greatly elevated anterior portion of the rostrum.

Color.—Type: Black from shoulders to base of tail, bright ochraceous-tawny, heavily mixed with dusky; sides, thighs and under parts paler, heavily washed with golden, and lacking the dusky suffusion; shoulders and nape of the neck black, with faint suggestion of russet; head black, occasionally washed with very dark brownish; face black; sides of neck and inner surfaces of upper forearms cream-colored, this color also occurring as a faint wash on the sides of the lower jaws; tail sharply bicolored, upper parts black for the entire length, sides and under parts bright ochraceous-tawny above the "palm;" feet black. The dusky suffusion of the back and the russet cast of the shoulders is more pronounced in some individuals, less so in others; this also is the case for the cream-colored wash on the sides of the lower jaw.

Skull.—The skull of the present form is so peculiar that on this basis alone it merits recognition as a distinct species. The nasal region of both males and females is greatly sunken with the result that the premaxilla has been thrown forward and upward, and the main axis of the first upper incisors is inclined 45° or more from the vertical, giving the skull a peculiarly prognathus appearance in lateral view, the toothrow being seen to curve very abruptly upwards anteriorly. The surface of the palate is deeply trough-shaped as compared to *geoffroyi;* the nasal bridge is narrower; the external nares smaller, and the distance between the lower border of the nares and the upper bases of the first incisors correspondingly greater. The orbits are laterally expanded so that they appear more oval and less round than in *geoffroyi.* Finally, the braincase is narrower and considerably higher, although the uplifted premaxillary region

tends to give the impression of a low forehead which the animal does not really have.

The present form differs externally from *geoffroyi* in its smaller size, blacker head and shoulders, and much paler sides, flanks, and sides of tail. The reddish cast of *geoffroyi* is almost entirely lost on the shoulders of *azuerensis* and is replaced by ochraceous heavily mixed with dusky. The skull characteristics ennumerated above further differentiate the animal. The specimens at hand vary considerably among themselves, some tending in certain characters towards *geoffroyi*. This form is given full specific instead of subspecific ranking, owing to the shortage of comparative material available from Panama and the unrevised condition of the group. Furthermore, the Azuero colony is in all probability fully isolated.

The type locality of *Ateles geoffroyi* is unknown. The present series was compared to specimens from the Canal Zone and the nearby mountains.

Considering the insular nature of the Azuero fauna, it is not surprising that the present form should differ from its mainland relative. The race is probably sharply limited by the savannah belt and "bush" lands at the head of the peninsula, since it is entirely dependent on a continuous forest of tall trees for overland travel. To be sure, the coastal "gallery" forest around Montijo Bay was once continuous[145] as far as western Chiriqui, but even when this was the case, that forest was interrupted by several deep and fairly wide tidal rivers (the San Pedro and the San Pablo) that served as effective barriers. If, as seems likely, the peninsula has been an island in the recent past, the differences in the two races are further explained.

Spider monkeys are far less often seen around Mariato than either howlers or white-faces; in fact, I myself never saw any close enough to be positively sure of their identity. Their apparent scarcity may in part be due to persecution by the natives as "los monos colorados" are considered excellent provender. According to Mr. Davies, who secured our four specimens, they travel habitually at higher levels in the trees than do the white-faces and are capable of much greater speed.

[145]Griscom, Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 3, April 1935, p. 270.

Measurements:

C. M. N. H. Number	Sex	Total Length	Tail	Hindfoot	Greatest Length of Skull (Exclusive of incisors)	Basilar Length	Palatal Length (From most anterior point on posterior border)	Length of Rostrum (From lower border of orbit)	Zygomatic Breadth	Width of Braincase	Upper Maxillary Toothrow (Alveolar borders)	Lower Maxillary Toothrow (Alveolar borders)	Greatest Width of Upper Molars	Nasal Bridge (Width at upper end of nasals)	Greatest Breadth of Left Orbit	Greatest Height of Left Orbit
1234	♀	1166	701	168	109.3	76.2	30.5	27.2	65.4	58.0	27.2	30.7	6.1	10.3	25.4	23.2
1235 Type	♀	1173	717	178	110.8	73.6	29.0	27.9	65.1	56.8	27.7	31.2	6.0	8.1	26.1	23.3
1236	♂	1153	720	170												
1237	♂	1170	720	177	109.5	76.6	31.0	29.9	66.9	54.5	29.5	33.1	6.1	8.4	23.6	20.2

Aotus bipunctatus sp. nov. AZUERO NIGHT MONKEY.

Type Locality.—Paracoté, three miles east of Montijo Bay, Mariato-Suay Lands, Veraguas Province, Panama.

Type.—Spec. No. 1204, adult female, Cleveland Museum of Natural History; collected by Pinkney Davies, March 19, 1932. Field Number: B-A 84.

Geographic Distribution.—Known only from the type locality,but probably distributed throughout the forested parts of the Azuero Peninsula, Panama.

General Characters.—A large, pale race with black markings reduced and heavy, massive rostrum and dentition; similar in external coloring to *A. griseimembra* of Colombia, but widely different cranially; close to *A. zonalis* of Panama.

Color.—Type: Back and sides pale wood-brown[146] lightly overlain with ochraceous-tawny along mid-line of back; the general

[146]Ridgway, Color Standards and Color Nomenclature. 1912.

color slightly darkened by scattered dark-tipped hairs; many of the hairs of the back and sides brightly burnished with pale golden straw-color; sides slightly paler than back; back of neck and shoulders grayer than rest of upper parts; underparts from light to pale ochraceous buff, slightly darker around groin and arm-pits; hind-limbs and upperparts of fore-limbs the same color as sides; underside of fore-limbs paler, suffused with color of underparts; feet slightly darkened by black-tipped hairs; tail suffused with russet, more and more heavily overlain with black from base to tip; terminal half of tail black; sides of head same as sides; top of head paler, but with narrow median line of black running between eyes over forehead; crown of head slightly darkened; two spots of clear white above eyes, many of their hairs white to their roots, others lightly tipped with black; a white ring surrounding the mouth, broken only by the nose; two grayish patches at bases of jaws, separated medially by a narrow line of ochraceous buff that is continuous with color of under parts.

Skull.—Similar to that of *Aotus zonalis* Goldman, but the facial angle more abrupt; the interorbital breadth (nasal bridge) greater; the rostrum much more massive; the braincase narrower and shorter, the distance from the foramen magnum to the rearmost point of the skull being less; inter-pterygoid fossa much narrower, especially anteriorly; molariform teeth larger.

Remarks.—*Aotus bipunctatus* is closely related to *A. zonalis* of the Panamanian cordillera and foothills. It is apparently a larger animal, however, and differes in a number of cranial characters, as set forth above. In coloring it is noticeably paler than *zonalis* everywhere, but it is in the coloring of the head that the two forms differ most markedly, the black markings of the crown of the present race being greatly reduced, the lateral ones being almost obsolete and the median one greatly narrowed. The blackened throat-patches of *zonalis* are pale grayish-buff in *bipunctatus;* and the two white spots below the eye in *zonalis* have become, in *bipunctatus*, a white ring encircling the mouth. Although this ring is clear white in the type, it is lightly overlain throughout its extent with dusky blackish in the one existing topotype, a male animal.

Aotus was the fourth species of monkey encountered by us in the Mariato River district. We were entirely unconscious of the presence of this animal until Mr. Davies succeeded in shooting two as they stuck their heads out of a hole in a hollow tree about fifteen feet above ground. They were, however, well known to the natives, who knew the species simply as "mono del noche." Because of their nocturnal habits they are never as familiar as the diurnal howlers and capuchins, and any estimate of the abundance in the region would be pure guess work, although the animal was not considered rare by our native porters. A strange wailing cry that we frequently heard in the night at the Mariato Rubber Camp, Altos Cacao and Cerro Viejo was ascribed to this species by them.

Measurements:

C. M. N. H. Number	Sex	Total Length	Tail	Hindfoot	Greatest Length of Skull	Basilar Length	Palatal Length (From anterior point of posterior border)	Length of Rostrum (From lacrimal border)	Zygomatic Breadth	Greatest Width of Braincase across Anterior Expansion of Temporals	Upper Maxillary Toothrow (crowns)	Lower Maxillary Toothrow (Alveolar borders)	Greatest Width of M. (Upper jaw)	Nasal Bridge (Width at narrowest)	Greatest Depth of Lower Jaw (Coronoid to angular)
1203	♂	839	430	101			19.8	13.8			18.4	19.5	3.4		29.5
1204 Type	♀	806	413	95	61.5	44.0	19.7	13.6	38.3	32.8	17.6	19.2	3.3	5.8	29.6

Procyon sp. RACCOON.

According to Goldman's account of the raccoons of Panama[147] *Procyon lotor pumilus* should be the commonest form to be found along the Mariato. No specimens were taken, but small coon-tracks were frequently seen in the mud of the mangrove-bottoms at low tide. From native descriptions we gathered that this was the animal usually known in the region as "gato de manglé," mangrove cat,

[147]Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, p. 151.

although that name was indescriminately applied to any animal vaguely resembling a cat that lived or was seen in mangroves. The animals ate crabs and various species of small snails, to judge from the remains seen about the mud-flats near the "port."

Another species of raccoon, *Procyon cancrivorus panamensis*, might possibly occur on the Mariato-Suay lands, although the species is unreported west of the Canal Zone.

Nasua narica panamaensis Allen. COATI-MUNDI.

Despite the extensiveness of the literature on the coati, both popular and scientific, no account of Panama mammals would be complete without some mention of this animal mountebank. As elsewhere in Panama, coatis swarm in the forests of the Mariato-Suay lands and are frequently seen in the course of daily wanderings through timbered country. They customarily travel in small bands of from five to twenty individuals that forage through all strata of the forests in quest of insect food. A company of coatis on foray is most amusing to watch as each mobile snout and absurdly long tail is gyrated in some new antic. The tails are as often carried straight up as not and seem to be of use in balancing the animals, to judge from the tame individual at large in the Paracoté plantation compound.

The particular specimen, a young male almost full-grown, was a constant source of interest and merriment. In a barnyard that teemed with chickens he had learned that game cocks had bad tempers and were dangerous; also that pursuing baby chicks, his favorite sport, was fraught with peril if those chicks were accompanied by their mothers. He was terrified of the mother cats of the premises, but enjoyed roughing up their kittens, which he did whenever the opportunity presented itself. When the chickens went to roost in a mango tree, he would, if the spirit moved him, rush out each limb knocking them off. He eventually learned to shake them off by leaping from branch to branch, thus setting the branches in such a commotion that the birds, in obedience to Newton's first law, parted company with their perches.

We tried to get this individual to eat meat, but he would have none of it. Insects he eagerly accepted, however, and was an inveterate robber of hens' nests and the laborers' pigeon-lofts, which ultimately led to his undoing. In the yard grew a tree dignified, according to Mr. Richards, by the name of soursop. The new-fallen fruit had all the tastiness of milk of magnesia and was shunned by all living things. As the fruit fermented in the tropical sunshine, a small species of wasp began to attend in numbers; and it was then that soursops became of interest to our coati. He would sit down in front of one, his head cocked to one side, his little ears forward and his mobile nose in ecstasies. When a wasp lit on the edge of the sticky mess he would slowly raise one paw, then swat the insect and rub it vigorously into the ground with the thick palm of his paw, keeping his "forefingers" raised up out of harm's way. This was terminated by a leap away from the scene of the death and was followed by long-range study of his victim's kind on the fruit. After apparent satisfaction that the wasp was safely disabled, and that no reprisals were forthcoming from the kin of the deceased, he would cautiously return, bare all his teeth by the most consummate withdrawal of his lips and nip off the offending end of the insect. This accomplished, he would eat the remainder, and immediately begin observations on a new wasp.

Interestingly enough, large iguanas that also inhabited the compound were terrified of this coati. Several times we saw them abruptly halted in the midst of a meal of hibiscus blossoms by the sight of him. They would immediately dash for the palm trees and disappear in their "collars" of dead leaves. Since the coati sometimes saw and sometimes failed to see them, but never showed more than a passing interest in any but one small one, it seems as though it was a normal carnivore reflex for the lizards. They paid no attention to the deer that lived in the compound, but were afraid of cats.

In the forests of the region, I met several lone coatis, presumably old males. One in particular resented my close approach and made several abortive charges, ending about fifty feet from me. When I again moved toward him he fled precipitately, tail erect. As other writers have noted, bands of coatis, when startled suddenly, rush to trees, climb up a few feet or to the lower branches to reconnoitre.

If then pressed, they rush headlong to earth to escape. During all this they utter a grunting alarm note.

Only three specimens were taken, although the opportunity to take many more was provided. All are from Paracote.

There seems to be some doubt as to the validity of the form *panamensis*, as distinguished from *bullata* of Costa Rica. Whatever the status of the Panama animal, the Azuero specimens at hand are perfectly typical of it.

Measurements:

C. M. N. H. Number	Sex	Total Length	Tail	Hindfoot	Greatest Length of Skull	Palatal Length	Zygomatic Breadth	Postorbital Constriction	Width of Braincase	Breadth across Bullae	Width of Left Bulla	Length of Left Bulla	Width of Upper M_3
1201													
2nd P_3's erupting 2nd C's erupted	♀	938	463	101	116.5	72.4	52.2	31.0	42.5	31.7	10.2	13.5	7.7
1202													
Old Adult	♀	1186	494	106	129.4	81.2	64.7	32.2	44.2	35.6	11.0	14.3	8.0
1260													
2nd P_3's erupted 2nd C's erupting	♂	1017	483	105	121.1	75.5	58.0	31.2	43.2	33.9	9.8	14.0	7.5

Potos flavus ssp. KINKAJOU.

On the second evening after our arrival at Paracoté, while I was setting traps on the port road just after sundown, an animal, then unfamiliar to me, crossed the road from the cocoanut plantation to the deep woods and immediately climbed into the brush along the edge of the road and the forest, disappearing into the trees at once. It was quite evidently a kinkajou. No sign of the species was discovered after that. This animal's tracks were studied, but none of them was seen subsequently in the dusty paths.

Bassariscus sumichrasti ssp. RING-TAILED CAT OR CACOMISTLE.

Tracks of *Bassariscus* were seen on two occasions in the roads around Paracoté. No specimens were taken and the natives, interviewed through Mr. Pinkney Davies, our guide, seemed unfamiliar with them.

Tayra barbara ssp. TAYRA.

A single individual of this species was encountered on a high ridge south of the Mariato Rubber Camp. The animal was running, ferret-like, from tree to tree at a distance of about 200 feet, but stopped at the base of one for half a minute while it smelled something very intently. It gave me an opportunity to observe it through a glass and to shoot at it. My shot went wild, and it forthwith disappeared over a steep bank into a deep dark ravine.

Lutra repanda Goldman. PANAMA OTTER.

Several otters were seen by members of the expedition in the interior mountains of the peninsula. Mr. Davies and Ignacio Alvarado, our native headman, reported seeing an otter on the Mariato River below our camp; I myself saw one above camp on the same stream. The animal was sunning itself on a rock projecting from a pool, but quietly glided into the water as I came into view. It crossed the pool under water and I caught a meagre glimpse of it as it disappeared into the thick under-brush along the stream's edge.

Mr. Aldrich, while sitting on the edge of a rushing mountain rill in the woods near Cavulla, saw two otters stick their heads out of a pool only a few feet from him. He fired point blank and is still nonplussed over their total and instantaneous disappearance. We finally had to purchase a skin from a native, the specimen having been taken along the Rio Negro below Altos Cacao.

This skin is that of a male animal. It is highly imperfect, all four legs, the nose, and most of the tail having been cut off. The color of the upper parts and under parts are precisely those given by Goldman in his original description of the species.[148] The only point

[148]Smithsonian Misc. Coll., Vol 63, No. 5; March 14, 1914, p 4

of divergence discernible from the somewhat meagre data at hand is the length of our specimen. While the skin is certainly badly stretched, it seems unlikely that this wholly accounts for the disparity between the total length given by Goldman and the body measurements available from our skin. The total length of the type of *repanda* is given as 1085 mm; the body alone of our specimen measures nearly 950. Apparently ours is the skin of a very large individual.

Herpailurus yagouaroundi panamensis (Allen). JAGUARUNDI.

Eyra cats are relatively common in the Mariato region, where they are abroad at all hours of the day and night. Their tracks were among the most conspicuous along the roads. Their reactions on being approached were very cat-like—they usually crouched, lowering the head, and hissed or growled or did both. The males greatly exceed the females in size. I saw four pairs in all during our stays at Paracoté and their actions were such as to indicate that smaller females were in heat at the time (February and March). The natives, to whom they were known as "gatos negros" or simply "gatos feos" (black cats or ugly cats) regarded them as inveterate poultry killers.

The female obtained at Paracoté was shot while she crouched hissing at me in full sunshine at a distance of less than thirty feet. The much larger male who accompanied her, although wounded, escaped.

Felis pardalis mearnsi Allen. MEARNS' OCELOT.

Ocelots are much less abundant around Paracoté than the eyras, but their tracks were seen regularly on the dusty roads through the plantations. I also saw their tracks in the wet sand of the river's edge above the Mariato Rubber Camp, and in the soft mud along a streamlet at Cavulla, so their altitudinal range is from sea-level to at least 3300 feet in the region.

They are frequently seen by the light of head-lanterns at night, which was the method by which our specimen, an old male, was obtained at Paracoté. The stomach of this animal contained remains,

in varying degrees of freshness, of *Sylvilagus*, *Proechimys*, and *Zygodontomys*, in addition to fragmentary and unidentified bird material.

Felis onca centralis Mearns. Central American Jaguar.

The "tigre" of the Panamanians, the jaguar of the American residents, is not, to judge from our failure to see any sign whatsoever of them, very abundant in the region. Hunters familiar with these mountains, including Mr. Davies, have all had various experiences with the big cats and are agreed that here, as elsewhere, they follow the roving bands of peccaries and razor-back hogs. Mr. Davies reported that on other trips into the Azuero Peninsula he had found tracks around his camp in the mornings, and had seen several of the beasts.

Felis concolor costaricensis Merriam. Central American Puma.

It was Mr. Davies' opinion that the puma was even scarcer in the country than the jaguar, but that like that animal it was most apt to be seen in the wake of the peccary droves. As in the case of the jaguar, we saw no sign of it.

Sciurus hoffmanni chiriquensis Bangs. Chiriqui Squirrel.

Sciurus (Guerlinguetus) aestuans chiriquensis Bangs, Bull. Mus. Comp. Zool. Vol. XXXIX, No. 2, p. 22, April, 1902. Type from Divala, Chiriqui.

Sciurus hoffmanni hoffmanni J. A. Allen, Bull. Amer. Mus. Nat. Hist., Vol. XX, p. 66, February 29, 1904.

Sciurus hoffmanni chiriquensis J. A. Allen, Bull. Amer. Mus. Nat. Hist., Vol. XXXIV, p. 220, May 17, 1915. There is an error here, the form in question being accidentally listed as *Microsciurus*.

Sciurus hoffmani chiriquensis Goldman, Smithsonian Misc. Coll. Vol. 69, No. 5, 1920, p. 137.

Allen[149] says concerning this squirrel: "As indicated above, *chiriquensis* may be regarded as a rather slightly differentiated form of *hoffmanni*, as the latter is here restricted, confined to the humid tropical lowlands of Costa Rica and Chiriqui, characterized mainly by thinner and more hispid pelage and the slightly more rufous tone of coloration. The characters given by Bangs, based on specimens

[149]Bull. Amer. Mus. Nat. Hist., Vol. XXXIV, 1915, p. 221.

from Divala (Chiriqui) specimens, are the reverse of the actual conditions, the words "more" and "less" in the expressions "more olivaceous" and "less brick-red" having been apparently accidentally transposed. The name, however, may be retained for the lowland form, in contradistinction to the form of the higher elevation of the interior, to which it seems convenient to restrict the name *hoffmanni* so far as the Central American representatives of the *hoffmanni* group are concerned."

The range of typical *hoffmanni* is an interrupted one, the form occurring in Costa Rica and not reappearing southwards until the Cauca Valley of Colombia is reached. I have compared the four specimens obtained by us to the type and topotypes of *chiriquensis* and to an extensive series of that form from various points in Chiriqui, all these specimens being in the collections of the Museum of Comparative Zoölogy at Harvard. At first glance the Chiriqui animals appear quite different from the small Mariato series, but when those taken at the same time of year as ours (March and April) are selected, the differences pretty largely vanish. There is a slight tendency towards a paler general color of the upper parts in one of two of our specimens, but the differences on the whole are exceedingly small. Cranially, there is a tendency in our series towards shortening of the rostrum as compared to the Chiriqui animals, but even this is not very pronounced. The characters of ours overlap those of the *chiriquensis* series in a number of cases and our specimens vary considerably among themselves. In external characters the Mariato animals seem to tend towards *hoffmanni* but cranially they are farther from *hoffmanni* than from *chiriquensis*.

Our four animals were all taken along the crest of the ridge separating the valley of the Mariato River from that of its tributary, the Rio Negro, at elevations of from 1500 to 2500 feet above sea level. Here we found them frequenting the scrubby, rather open ridge-top woods and would often allow a rather close approach. The species is not confined to any elevation on the peninsula, how-

ever, as Mr. Aldrich saw two in brushy second-growth at Paracoté and I saw one south of Cavulla at an elevation of nearly 4000 feet. They were rather common about Cavulla, and one lived in a large hollow tree beside our campsite. These squirrels also inhabit the small islands in Montijo Bay, Cebaco and Gobernador, which are only a few miles off the Azuero shore and from which the British Museum has specimens.[150]

Upon surprising one animal at close range, I heard it emit a series of short husky "barks" terminating in a series of "chucks" reminiscent of its northern relative, the fox squirrel. All the others I saw were silent even when startled.

Two of the females were nursing young at the time they were taken, (March 6 and 8, 1932). Specimens obtained: Altos Cacao, 1; Cerro Viejo, 3.

Measurements:—

Spec. No.	Sex	Length	Tail	Hindfoot	Skull: Greatest Length	Zygomatic Breadth	Interorbital Constriction	Breadth of Braincase	Nasals (along midline)	Maxillary Toothrow (alveolar)
1192	♀	362	150	51	49.0	29.6	15.5	23.6	13.8	8.3
1193	♀			53	50.0	30.1	15.1	23.8	13.8	8.5
1197	♀	368	157	49	49.1		16.9		14.8	8.4
1198	♂	365	164	53	48.5	30.2	15.8	24.2	13.6	8.1

Sciurus variegatoides melania (Gray). COSTA RICAN BLACK SQUIRREL.

1867 *Macroxus melania* Gray, Ann. and Mag. Nat. Hist. Ser. 3, Vol. 30, p. 45.

1902 *Sciurus melania* Bangs, Bull. Mus. Comp Zool., Vol. XXXIX, No. 2, p. 22, April, 1902.

[150]See Thomas, Nov. Zoöl., Vol. 10, 1903, pp 34-42.

1920 *Sciurus variegatoides melania* Goldman, Smithsonian Misc. Vol. 69, No. 5, p. 136, April 24, 1920.

Up to the present time *Sciurus variegatoides melania* has been known from western Panama and Costa Rica, and from several islands off the southwest coast of Panama. It has not been known from points east of Chiriqui on the mainland, a specimen from Remedios, Chiriqui and from points farther east having been referred to *Sciurus variegatoides helveolus* Goldman. All of the known specimens of *melania* have been black in color; all of *helveolus*, chocolate and buff, with black and white tail. In the Mariato River district both color phases occur and both are of the same subspecies. In the course of the expedition under discussion, four specimens were obtained, three black and one parti-colored, all shot in exactly the same locality. The two color phases were seen together several times and in other places, and natives assured us that both phases often were found in the same nests. In addition to this evidence, I compared our four specimens to examples of *melania* from Chiriqui and *helveolus* from the Canal Zone; they are indistinguishable cranially from either; the black ones are identical to the black Chiriqui *melania* and the parti-colored one is very close to *helveolus*, although somewhat less grizzled on the back. However, all four specimens have the rudimentary upper premolar characteristic of *melania*, although in the case of one, a black animal, this tooth is missing on one side. I therefore consider it possible that when larger series are available, *helveolus* may prove to be a synonym of *melania*, unless *melania* in turn proves synonymous with some other more northern form. In the district under consideration the black *melania* type squirrels are definitely melanistic individuals of the part colored animal and no more separable from it than is the black squirrel of the northeastern United States from the Northern Gray Squirrel.

These squirrels were seen only in the coastal lowlands and seemed to prefer womewhat older denser woodland than *hoffmanni*, although Mr. Aldrich obtained specimens from the open growth of an abandoned plantation site. They were seen eating young mangoes, but were so wild and wary that little note could be made of their habits.

Measurements:—

Species Number	Sex	Length	Tail	Hindfoot	Length of Skull—Anterior border of foramen magnum to tip of nasals	Zygomatic Breadth	Interorbital Constriction (taken anterior to postorbital process)	Breadth of Braincase	Nasals (along midline)	Maxillary Toothrow (left alveolar)	Remarks
1215	♀	553	263	67	60.0	34.8	19.9	25.4	18.6	11.9	Rudimentary premolar absent on left side of upper jaw, *Melania*–type; black
1244	♀	562	281	67	60.1*35.7		21.3	27.8	18.0	12.5	*Melania*–type; black
1257	♂				60.3*35.7		21.1	26.5		12.3	*Melania*–type; black
1258	♂	540	272	65	60.3	35.3	20.1	26.2	18.6	12.2	*Helveolus*–type; particolored

*In these two individuals the greatest length of the skull is that from the occipital projection to the tips of the nasals, not the one given above. In the other two the greatest length is the measurement given.

Liomys adspersus (Peters). PANAMA SPINY POCKET RAT.

Presumably the brushy and weedy margins of the dry llanos around Paracoté and the drier locations in the near-by cocoanut plantations should provide an ideal habitat for a spiny pocket-rat of the genus *Liomys*. In spite of the apparent suitability of the terrain, however, only two specimens were taken. Both were captured in heavy grass and weeds in much the same sort of places that cane and cotton rats inhabited along the plantation roads. Their cheek pockets in both cases were filled with several types of weed seeds and some tiny greenish fruits. The two animals were entirely clear of external parasites except for a few redbugs around the groin of the larger specimen.

One of our specimens is an adult male, the other a half-grown young animal, badly mangled by ants. Its sex is indeterminable. The male is the only existing adult specimen of its sex, only nine examples of this species having been collected to date. In fact,the only other completely adult specimen is a female in the collection

of the Biological Survey, No. 179575. The Field Museum's specimen. number 19132 is nearly adult. It also is a female. Our male animal, number 1193, is very much larger than any of the other specimens, as may be noted by comparing its hindfoot measurement of 33 mm, with that of the other adult, Biological Survey No. 179575, which is 31.5 mm. It is to be regretted that the skulls of both these animals are imperfect.

These records from Paracoté constitute the only noteworthy extension of the known range of this form that has been reported, all the other specimens having come from the Canal Zone. The adult male in question differs from the Canal Zone animals only the slightly more ochraceous tipping of the small hairs that project above the animal's spiny armament. It is otherwise indistinguishable.

Measurements:—

Species Number	Sex	Length	Tail	Hindfoot	Greatest Length of Skull	Zygomatic Breadth	Interorbital Constriction	Width of Braincase	Length of Nasals	Palatal Length	Interparietals (Breadth times length)	Maxillary Toothrow (Alveolar borders)	Remarks
1193	♂	262	121	33		18.6	7.8	15.3	16.4	14.4	7.9	6.1	Old adult, teeth well worn.
1223	Juv.	186	93	28	29.0	13.3	7.0	13.0	11.0	11.2	x3.9	5.3	M_3 just erupting.

Oryzomys azuerensis sp. nov. AZUERO RICE RAT.

Type Locality.—Paracoté, 1½ miles south of the Angulo River Mouth, Mariato-Suay Lands, Veraguas, Panama, Altitude of type locality, sea level.

Type.—Spec. No. 1178, young male, about two-thirds grown, skin and skull, Cleveland Museum of Natural History. Collected by B. P. Bole, Jr., February 19, 1932. Original Number: B-A 58.

Distribution.—Known only from type locality.

General Characters.—A brownish member of the *couesi* group, lacking the ochraceous suffusions of the nearby races and having a short, broad skull with well-marked supraorbital shelves.

Color.—Upper parts near Prout's brown,[151] slightly paler on sides; somewhat lighter on cheeks and sides of neck, where there is a very faint suffusion of ochraceous buff; much darkened on the top of the head, the color near mummy brown. The dark guard-hairs of the back are mummy brown or bistre, not black. Underparts pale, dull gray, with the faintest suggestion of buffy wash. Outer sides of ears blackish, inner sides clothed with bright ochraceous buffy hairs; feet sparsely covered with short brownish hairs that are conspicuous against the lighter-colored skin; tail dark brownish above, paler below except at tip, finely annulated and nearly naked.

Skull.—Short and broad, nearly 2 mm. shorter than that of the type of *gatunensis*, but with greater zygomatic breadth and wider braincase. The shortness of the skull is largely in the rostrum, which completely differentiates its appearance from that of the skulls of the forms *gatunensis*, *richmondi*, and typical *couesi*.

Measurements.—Length, 203 mm.; tail, 107.5; hindfoot, 30. Skull: greatest length, 25.8; interorbital breadth, 4.8; zygomatic breadth, 14.6; width of braincase, 12.6; length of nasals, 9.7; anterior palatine foramina, 5.0; palatal bridge, 5.1; upper molar series (alveolar borders), 4.5. The interparietal of the skull of the type, a feature in which this form differs from *gatunensis*, is imperfect and cannot be measured accurately.

The above described specimen was taken in a grassy salt-water drainage ditch in the cocoanut plantation at Paracoté. It was recovered after an unusually high tide, which permitted a large green crab to remove the skin of the lower jaw. The specimen is otherwise intact and was the only one taken.

I was not sure just what the animal was while I was in the field, but upon my return I ran it down in Goldman's rice-rat key[152] to *Oryzomys gatunensis* Goldman on the basis of its ownership of supraorbital shelves. In other characters, however, it differed notably from the published descriptions of that form. Accordingly I submitted

[151]Ridgway, Color Standards and Color Nomenclature, 1912
[152]N. Amer. Fauna, No 43, pp 17, 18

it, while visiting the Museum of Comparative Zoölogy, to Dr. G. M. Allen, who also was unable to place it elsewhere than under *gatunensis*. Subsequently I sent it on to Major Goldman at Washington. He very kindly compared it to the type and only existing specimen of *gatunensis*. Two paragraphs from his letter regarding the matter follow:

"Your specimen compares with the type of *gatunensis* as follows: Size similar; pelage shorter, perhaps due to a little earlier stage of development; color browner above and grayer below, lacking the ochraceous tawny suffusion of upper parts and ochraceous buffy under parts in the type; skull somewhat shorter, more robust; brain case larger, more inflated; rostrum shorter and heavier; frontal region similarly broad; zygomata more widely spreading; interparietal larger, more extended antero-posteriorly; nasals exceeding premaxillae in posterior extension much as in *gatunensis*; dentition about the same.

"Your specimen compares with typical *couesi* of similar age as follows: Size similar; color browner above and grayer below, lacking ochraceous tawny suffusion of upper parts and ochraceous buffy of under parts; skull somewhat shorter, more robust; brain case larger, more inflated; rostrum shorter and heavier; frontal region broader; supraorbital ridges more prominent than usual in *couesi* of corresponding age, but incidentally a trifle less trenchant than in the type of *gatunensis*; zygomata more widely spreading; interparietal about the same; nasals extending posteriorly beyond premaxillae (ending in about the same transverse plane in couesi)."

Major Goldman goes on to recommend the treatment of this specimen as a subspecies of *couesi*, adding that *gatunensis* is probably a geographic race of that species. Because of the fact that there is a huge gap between the nearest station of *Oryzomys couesi* (extreme northwestern Costa Rica) and the Azuero Peninsula, plus the additional fact that *azuerensis* is not strictly intermediate between *couesi* and *gatunensis*, but diverges from both in several characters, it seems a bit more prudent to describe this form provisionally as a full species, in view of the total lack of specimens of this group from most of Costa Rica and all of Panama west of Veraguas.

I myself have compared the specimen at hand to a series of *O. couesi richmondi* from eastern Nicaragua. Young of the same age and adults too are entirely different in color in that form from my specimen, while the same difference that Major Goldman mentions between the skulls of *azuerensis* and typical *couesi* hold, or are intensified, in the case of *richmondi*. The olivaceous and ochraceous tones of *richmondi* are entirely missing in *azuerensis*.

It is a fortunate thing for the identification of this animal that the type of *gatunensis* is of comparable age.

Oryzomys talamancae Allen. TALAMANCA RICE RAT.

Oryzomys talamancae, Allen, Proc. U. S. Nat. Mus., Vol. 14, p. 193, July 24, 1891. Type from Talamanca, Costa Rica.

Two very large individuals of this species were all that I was able to save out of a series of five taken under logs on the bank of a woodland stream at Paracoté. The other three were so badly torn to pieces by ants and larger animals that they were discarded after I had made sure that they were the same as the two at hand. My specimens are both much more richly colored than the average of specimens I have seen from the Canal Zone, and seem to have a tendency towards rather short incisive foramina; but, as they are not entirely similar to each other and are very close to specimens from Cana in eastern Panama, they are here referred to *O. talamancae*. Both are rather old individuals which doubtless accounts in part for their brightness of coloration.

This rice rat is apparently only locally abundant in the region under consideration. Enders[153] indicates that on Barro Colorado Island these rats are found throughout the forest during the dry season. Such is apparently not the case in the Mariato region, as none was taken anywhere except in deep, moist ravines or in floodplain woods close to the seashore. A single mangled specimen was taken at the Mariato Rubber Camp and was discarded.

Both specimens saved were entirely free of ectoparasites. Their measurements may be of some use and are here recorded. Both animals were taken at Paracoté, Mariato-Suay Lands, Veraguas, at an altitude of about 100 feet.

Measurements:—

Species Number	Sex	Length	Tail	Hindfoot	Occipitonasal Length of Skull	Zygomatic Breadth	Interorbital Consuriction	Length of Nasals	Incisive Foramina	Maxillary Toothrow
1140	♂	271	135	31	32.6	26.8	4.7	12.5	4.5	4.5
1134	♂	279	140	31		26.1	5.1	11.6	5.0	4.7

[153]Bull. Mus. Comp Zoöl., Vol. LXXVIII, No. 4, October 1935, p 451.

Sigmodon hispidus borucae Allen. BORUCA COTTON RAT.

Sigmodon borucae Allen, Bull. Amer. Mus. Nat. Hist., Vol. IX, p. 40, March 11, 1897.

Sigmodon hispidus borucae Bailey, Proc. Biol. Soc. Washington, Vol. 15, p. 112, June 2, 1902.

Sigmodon hispidus chiriquensis Goldman, Smithsonian Misc. Coll., Vol. 69, No. 5, p. 106 (1920).

The status of the cotton rats of western Panama will be clarified only when fairly complete collections are available from all parts of Chiriqui, Veraguas and Coclé. Allen[154] described as new the cotton rat inhabiting the Boqueron district of Chiriqui, recognizing the differences between it and *S. borucae* from Boruca, Costa Rica, which he had earlier described.[155] The first reference to *Sigmodon* in Veraguas was by Alston, who referred animals from northern Veraguas to the species *hispidus*[156] but did not attempt to define their subspecific rank. All subsequent writers until the appearance of Goldman's "Mammals of Panama" in 1920,[157] with the exception of Allen, as noted above, referred their Panama cotton rats to *borucae*, including Bangs,[158] Thomas,[159] and Anthony.[160] Goldman, however, referred all the cotton rats of Panama to *chiriquensis*[161] and his lead has recently been followed by Enders.[162]

I have examined Costa Rica examples of *borucae* and have compared them to the series obtained in the Mariato River country, and am quite unable to detect any constant differences. Chiriqui animals from Bugaba, listed by Goldman[163] under his general account of *S. hispidus chiriquensis*, differ from the Mariato series in their considerably richer and darker coloration, which is especially noticeable on the hind feet. They are clearly referable to *chiriquensis*, the type locality of which (Boqueron) is not far away (only five miles) and at a slightly higher elevation.

Specimens from the Canal Zone, kindly lent for comparison by the Biological Survey, are also indistinguishable from the Mariato series, the only differences being minor ones in the skulls of a few individuals. Therefore it seems best to refer the present series to

[154] Bull Amer. Mus. Nat. Hist., Vol. XX, February 29, 1904, p. 68
[155] Bull Amer. Mus. Nat. Hist., Vol. IX, March 11, 1987, p. 40.
[156] Biologia Centrali-Americana, Mammalia, 1879-1882. p 152
[157] Smithsonian Misc Coll., Vol. 69, No. 5, 1920, pp. 1-309
[158] Bull. Mus. Comp. Zoöl., Vol. XXXIX, No. 2, April, 1902, p. 32.
[159] Nov. Zoöl., Vol. 10, April 1903, p. 41.
[160] Bull. Amer. Mus. Nat. Hist., Vol. XXV, June 9, 1916, p. 368.
[161] Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, pp. 1-309.
[162] Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 455

borucae, although the range of this form, as thus determined, is almost or wholly divided in two parts by the range of *chiriquensis* in western Chiriqui. Further collections from western Chiriqui are eminently desirable.

Cotton rats proved to be almost strictly diurnal at Paracoté, as only two were taken before our traplines were kept functioning by day as well as by night. When I began rebaiting my traps in the mornings a small series was soon captured. These rats made indistinct runways like those of *Zygodontomys*, with which genus of rats they are constantly associated at Paracoté, the same traps often yielding the two forms on alternate days or in the evening and morning. In general cotton rats seem to prefer heavier ruderal growth than the cane rats, as none was taken in the grassy llanos or along their edges. All of the Paracoté series came from the cocoanut plantations, which are heavily overgrown with thick grass and weeds.

Young of all ages were taken, and one nest was discovered. I stepped through the roof of this nest, which was situated about nine inches under-ground in easily friable soil. The chamber was of irregular shape and was grass-lined; there were several tunnel leading into it. There were about half a dozen young at home at the time, one of them being crushed under foot when I broke through the roof. The others, just old enough to climb about, escaped into the tunnels.

One female *Sigmodon* contained the astonishing total of seventeen embryos, each about half an inch in length; another contained eleven, and a third but three. If they are usually so capably prolific, it is a cause for amazement that they do not greatly outnumber *Zygodontomys*, the commoner genus. Our catch of *Sigmodon* and *Zygodontomys* together comprised over half of our total catch of mammals during the course of the expedition.

Specimens.—Paracoté, 17; Cavulla, elevation 3300 feet, 1. About twenty others were discarded at Paracoté.

Measurements:—

C. M. N. H. Number	Total Length	Tail	Hindfoot	Skull: Greatest Length (Occipitonasal)	Zygomatic Breadth	Interorbital Breadth	Nasals (Length)	Width of Braincase (Taken anterior to descending process of supraoccipital)	Width of Rostrum (Maxillae at antorbital notch)	Length of Interparietal (At median line)	Maxillary toothrow (Alveoli)
Males											
1145	243	106	30	31.1	18.0	5.2	10.6	12.7	5.8	3.1	6.2
1161	224	97	28	29.6	16.9	4.9	10.3	12.4	5.5	3.0	6.3
1212	244	102	29	32.6	18.3	5.0	11.6	12.8	5.8	3.5	6.9
1227			31	36.0	20.0	5.3	13.3	13.5	6.4	2.8	6.5
1244				32.4	18.6	5.2	11.8	13.0	5.8	2.8	6.1
1245	236	98	28								
1246	251	102	35	32.4	18.5	5.2	11.6	13.2	5.8	2.5	6.2
1247	264	114	32	33.3	18.6	5.2	11.9	13.4	6.1	3.0	6.1
Averages	243.7	103.2	31	32.5	18.4	5.1	11.6	13.0	5.9	2.9	6.3
Females											
1213	241	104	31	30.3	18.0	5.0	10.3	12.9	5.5	2.6	5.7
1216	233	107	31.5	30.0		4.8	10.2	13.0	5.8	2.2	5.8
1226	235	100	28	30.5	17.6	5.0	11.0	12.6	5.5	2.7	6.1
1253	262	111	29	33.6	18.5	5.2	11.8	13.1	5.5	2.9	6.0
Averages	242.7	105.5	29.9	31.1	18.0	5.0	10.8	12.9	5.8	2.6	5.9
Biol. Survey											
Males											
170973	272	115	33.5	33.9	20.0	5.3	12.1	13.5	6.1	2.2	6.1
171257	270	108	32.5	33.7	18.9	5.3	12.2	13.3	5.9	2.2	5.9
171249	257	109	33.5	34.5	20.0	5.6	13.0	13.3	6.4	2.3	6.3
171247			32	34.5		5.3	12.8	13.4	6.4	2.5	6.0
Averages	266.3	110.7	32.9	34.15	19.6	5.4	12.5	13.8	6.2	2.6	6.1
Females											
171252	270	111	32.5	34.1	19.5	5.5	12.5	13.2	6.5	2.1	6.0
171255	261	110	32	33.2	18.8	5.7	11.5	13.2	6.2	2.4	5.8
171256	291	128	32.5		19.6	5.5	11.9		6.3		6.0
171523	251	101	33.5	32.7	18.5	5.1	12.2	13.3	6.1	2.1	5.8
Averages	268.2	112.5	32.6	33.3	19.1	5.5	12.0	13.2	6.3	2.2	5.9

Nyctomys sumichrasti ssp. VESPER RAT.

Along one of my forest traplines at Paracoté I placed a rat trap on a leaning tree-trunk about fifteen feet above the ground. It yielded on successive nights, the hopeless mangled remains of a *Marmosa mexicana*, a *Proechimys*, and the hind foot and tip of tail of an arboreal rat of some sort. From the coloroing and shape of the fragments, I recognized them as the remains of a specimen of some race of *Nyctomys*, a genus of vesper rats, and one which frequently reaches Cleveland in banana shipments. No other trace of the animal was noticed at Paracoté.

At Altos Cacao our camp was situated on the crest of a ridge between jungle-choked ravines. From a spring at the bottom of one of these we got our water, and we washed in a small pool just below it. On evening at dusk when I was washing my hands, two of these rats appeared on the side of a liana-covered tree trunk less than fifteen feet from me. After hesitating for a moment, one pursued the other around and around the trunk much as chipmunks do. One of them finally stopped in plain sight on the fold of a crinkly liana and watched me, its blackish tail hanging straight down, making a most attractive picture. There it stayed for but a moment, then disappeared either into the dense underbrush behind the tree or up the tree on the side away from me. On the next evening I again startled one of these creatures near the pool. This time it came part way around the trunk to look at me, then fled at once, going up the tree.

With all this provocation, I covered the vicinity with traps, using all the baits at our disposal. The only yield was a *Proechimys*.

At Cavulla these rats were heard scurrying about on tree trunks and branches along the ravine beside our camp. I was finally able to turn the beam of a flashlight full on one of them. It sat blinking for an instant on a small branch twenty feet above ground, seated

crosswise with its tail hanging vertical. I was unable to duplicate the performance and no specimens were taken despite intensive efforts.

Such is the evidence of the occurrence of *Nyctomys* on the Azuero Peninsula. According to Goldman[164] the form *nitellinus* is typical of the Upper Tropical Zone, although our Cleveland stowaways always originate in banana plantations close to sea level. Our Paracoté record belongs to the most basal lower tropical—the edge of a mangrove swamp.

Zygodontomys cherriei ventriosus Goldman. CANAL ZONE CANE RAT.

Cane rats are by far the commonest mammal of the open country around Paracoté. They are confined to the open llanos, weedy places along roads, recently cleared land and the cocoanut plantations, where I was able to take nearly a hundred individuals of all ages, although not all were saved. They apparently are nocturnal in habit as none was taken in the daytime although our traps were rebaited morning and evening after the first few days. They made runways only in the thickest grass and these were never as well marked or as pronounced as those made by our northern *Microtus* whose ecological niche cane rats fill at Paracoté. Many of even these runways may have been made by *Sigmodon* which we always found in the same sort of environment and often caught on the same traplines. They came readily to fruit and rolled oats used as bait and it was possible to catch them in mouse-traps set in the middle of roads, several feet from cover. The dust of roadways was often peppered with their tracks in the morning, showing that they had made many transits from cover to cover during the night.

Several nests were found and all were of grass and down of the flowers of an unidentified plant. They were most frequently situated

[164]Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, pp. 1-309.

just under the surface of the ground near the edges of the ditches along the roadways, from which underground entrances led to the nest. Other entrances were furnished by short tunnels into the nests from the landward sides of the ditches and runways usually fed the holes at the ends of these. One nest was found in very thick grass directly on the surface; three nearly full-grown individuals were driven from it.

The series at hand contains animals of all ages from quarter-grown young to shaggy old adults, and many of the females contained embryos of different sizes. Four was the usual number, but the totals varied from two to eight and one female contained eleven.

Ruderal growth seems to be the favorite habitat of these rodents, as not one was taken even in second growth woods, and only two in the open llanos far from weedy cover. About the edges of the llanos they were common, however, because it was here that low bushes and thick weeds were abundant. Enders[165] mentions the continued existence of one animal inside the Barro Colorado Laboratory, apparently of its own choice; it is interesting in this connection that I took one in the bathroom of the plantation house at Paracoté in a rat trap that had captured a *Rattus* the previous night.

A single specimen was taken in an abandoned native hillside garden at Altos Cacao at an elevation of about 1500 feet. Densely forested mountains surrounded this spot for miles, so apparently *Zygodontomys* passes through forested areas readily.

These Mariato specimens show much variation, but are on the whole identical to *Z. cherriei ventriosus*, being much larger and uniformly paler than the Chiriqui animals referred by Goldman[166] to typical *cherriei*. The darkening along the back characteristic of that form is missing in the present series. Measurements of the adults of the series follow:

[165]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 455.
[166]Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, p. 107.

Measurements:

C. M. N. H. Number	Total Length	Tail	Hindfoot	Occipitonasal Length of Skull	Greatest Zygomatic Breadth	Interorbital Constriction	Greatest Width of Braincase (Across squamosals)	Length of Nasals	Incisive Foramina	Width of Rostrum (Posterior border of Premaxilla)	Interparietal (at median line)	Maxillary Toothrow (alveolar)
Males												
1123	185	87	23	25.7	13.4	4.5	11.1	9.6	5.3	4.4	3.2	4.1
1125	201	84	24	26.4	14.0	4.4	11.3	10.3	4.7	4.6	3.8	4.1
1126	229	92	26	29.2	15.2	4.6	11.8	11.7	5.3	5.2	4.0	4.1
1131	220	85	24		14.8	4.8	12.1	11.0	6.0	5.0	2.9	4.4
1136	249	110	25		15.8	4.8	12.5	11.5	6.4	5.0	3.0	4.3
1138	192	82	23	25.7	13.5	4.5	11.6	9.4	5.1	4.3	3.0	4.0
1139	229	99	25	29.1	14.9	4.6	12.0	11.7	5.9	4.9	2.7	4.5
1144	230	94	26		15.7	4.7		12.0	6.4	5.2		4.3
1146	204	87	26	27.7	14.1	4.4	11.5	10.6	5.5	4.6	3.6	4.2
1147	203	84	24	27.2	14.3	4.4	12.0	10.0	5.3	4.6	3.6	4.4
1149	195	86	24	25.6	13.1	4.3	11.6	9.6	4.7	4.3	3.0	4.2
1151	199	83	24	26.1	13.5	4.7	11.6	9.6	5.1	4.5	3.1	4.2
1152	243	95	26			4.5		11.0	5.7	4.6	2.8	4.6
1153	190	85	23		13.7	4.6	12.0	10.0	5.4	4.5		4.4
1155		95	25			4.5	11.5	11.0	5.5	5.1		4.3
1160	208	86	25	27.2	13.6	4.2	11.2	10.2	5.3	4.5	2.6	4.1
1163	232	104	26	29.5	15.0	4.9	12.0	11.3	5.8	5.0		4.2
1168	200	92	25	27.3	14.2	4.5	12.0	10.6	5.8	4.5	3.1	4.3
1169	199	93	24	27.4	14.1	4.7	11.8	10.9	5.8	4.4	3.4	4.3
1170	211	87	24	28.1	14.3	4.9	11.8	10.6	5.8	5.2	3.3	4.8
1171	233	97	25	30.9	16.0	5.0	12.8	12.3	6.6	5.8	4.6	4.5
1176	181	89	25		12.9	4.3	11.4		5.0	4.4	3.3	4.2
1177	209	96	26	28.6	14.8	5.2	12.3	10.4	6.1	5.1	3.2	4.7
1188	212	89	26	28.7	14.4	5.0	11.8	10.8	5.7	5.1	3.6	4.7
1207	213	87	24	28.2	19.2	4.7	11.6	10.5	6.0	4.8	2.6	4.6
1209	200	85	23	26.7	13.7	4.5	11.2	10.5	5.5	4.4	3.1	4.2
1222	235	100	26	30.2		4.9	12.2	11.4	6.2	5.4	3.9	4.5
1229	190	86	24	26.0	13.6	4.9	11.0	9.3	5.4	4.9	3.4	4.3
1230	225	99	25	27.9	14.7	4.7	11.7	10.2	5.8	5.1	2.7	4.3
1231	242	102	27	30.2	15.5	5.0	12.0	12.2	6.1	5.2	3.1	4.5
1232	190	87	24	26.2	13.0	4.6	11.2	9.4	5.5	4.4	3.4	4.4
1239	235	96	26	30.0	15.4	4.6	12.2	11.6	5.8	5.1	2.3	4.6
1240	239	106	27	31.0	16.0	4.2	12.5	12.7	6.2	5.2	2.8	4.6
1243	212	93	24	28.9	14.7	4.9	12.3	10.5	6.2	5.0	3.3	4.5
1249	238	104	25	29.9	15.6	4.9	12.2	11.4	6.0	5.2	2.5	4.6
1250	237	103	26	28.3	14.8	4.5	12.0	10.7	5.9	4.5	2.8	4.2
Averages	214.6	92.6	24.9	28.1	14.4	4.6	11.8	10.8	5.7	4.9	3.2	4.4

Measurements:

C. M. N. H. Number	Total Length	Tail	Hindfoot	Occipitonasal Length of Skull	Greatest Zygomatic Breadth	Interorbital Constriction	Greatest Width of Braincase (Across squamosals)	Length of Nasals	Incisive Foramina	Width of Rostrum (Posterior Border of Premax.)	Interparietal (At median line)	Maxillary Toothrow (Alveolar)
Females												
1121	174	75	22		12.5	4.6	11.0		4.9	4.2	3.5	4.1
1124	191	82	24		14.0	4.5	11.4	10.2	5.4	4.5		4.1
1148	207	89	23			4.6		11.5	6.5	4.9		4.4
1159	180	82	22	25.1	13.1	4.2	11.6	9.1	5.1	4.1	2.0	4.3
1164	201	84	24			4.6		9.5	5.8	4.5	3.3	4.4
1165	240	101	25	29.4	14.9		12.5	12.0	6.5	4.9	2.9	4.1
1166	218	93	23	28.4	14.4	4.3	12.0	11.2	5.6	4.9	2.7	4.6
1208	206	88	24	27.3	14.1	4.8	11.7	10.0	5.6	4.9	2.8	4.1
1210	197	88	24		13.6	4.4	11.4		5.5	4.6	3.2	4.2
1211	203	91	22	26.1	13.7	4.2	11.5	9.8	5.5	4.4	3.3	4.2
1218	201	88	24	27.5	13.9	4.6	11.7	10.9	5.9	4.4	2.6	4.3
1219	193	85	24					9.8	5.1	4.8	3.2	4.3
1220	188	77	21	25.6	13.5	4.6	12.1	9.6	5.1	4.4	2.9	4.2
1228	199	90	25	27.1	13.6	4.4	11.3	10.6	5.6	4.7	2.6	4.3
1229				26.1	13.4	4.8	11.0	9.5	5.6	4.7	3.0	4.2
1233	191	85	21	26.1	13.0	4.5	11.4	9.5	6.2	4.2	2.3	4.3
1238	210	92	23	28.0	14.6	4.5	11.8	10.3	5.8	4.6	2.2	4.7
1241	183	80	23	27.0	13.5	4.5	11.6	10.0	5.9	4.7	2.5	4.4
1242	226	96	24	29.0	15.2	4.9	12.1	11.2	6.3	5.0	2.5	4.2
1248	229	88	24	29.0	15.1	4.6	11.8	10.6	6.5	5.2	2.2	4.5
Averages	201.9	86.8	23.3	27.3	13.9	4.53	11.64	10.3	5.72	4.63	2.76	4.29

Measurements:

C. M. N. H. Number	Total Length	Tail	Hindfoot	Occipitonasal Length of Skull	Greatest Zygomatic Breadth	Interorbital Constriction	Greatest Width of Braincase (Across squamosals)	Length of Nasals	Incisive Foramina	Width of Rostrum (Posterior border of premax.)	Interparietal (at median line)	Maxillary Toothrow (Alveolar borders)	M_3 Development
Juvenile Males													
1122	181	80	23	25.2	12.7	4.2	10.7	8.9	4.7	4.3	3.7	4.3	M_3 fully erupted
1157	160	70	21	24.2	12.5	4.3	11.1	8.5	4.9	4.0	3.7	4.5	M_3 almost fully erupted
1167	179	84	23	24.5	12.8	4.5	11.5	8.6	4.9	4.5	3.3	4.7	M_3 fully erupted
1175	151	70	21		11.9	4.5	11.0	8.3	4.7	4.1	3.0	4.7	M_3 just emerging
Juvenile Females													
1128	154	64	21	23.3	12.0	4.4	11.4	8.2	4.8	4.2	3.1	4.5	M_3 fully erupted
1156	149	66	20	22.2	11.5	4.6	10.6	7.7	4.6	3.9	2.6	3.5	No sign of M_3 yet
1158	133	57	19	22.0		4.4	10.6	5.1	4.6	4.1	3.0	4.4	M_3 just starting

Rattus rattus rattus (Linnaeus). BLACK RAT.

Black rats inhabit the various buildings of the Paracoté settlement, where they do the usual amount of damage. They also wander out into the cocoanut plantations on occasions, as I saw one of these creatures descend from a cocoanut tree and run across the beach road into thick weeds one evening. Two specimens were taken in rat-traps inside the main building of the plantation. The rats inhabiting native huts and gardens on the Mariato-Suay property away from the seacoast are usually *Zygodontomys* and *Proechimys*, not *Rattus*. No trace of this introduced species was discovered in the interior of the Mariato-Suay region.

Proechimys semispinosus goldmani ssp. nov. AZUERO SPINY RAT.

Type Locality.—Altos Cacao, Mariato-Suay Lands, Veraguas Province, Panama. (Altitude 1500 feet, on the ridge between the Mariato and Negro Rivers.)

Type.—Spec. No. 1191, adult male, Cleveland Museum of Natural History; collected by B. P. Bole, Jr. on March 3, 1932. Field Number B-A 71.

Geographic Distribution.—Azuero Peninsula of Panama, probably on both slopes of the mountains, but known only from the western (Veraguas) side.

General Characters.—A dark, dull-colored, slightly differentiated race with a number of cranial characters peculiar to it.

Color.—Type: Upper parts between argus brown and Mars brown[167] the color being given by the dark bone-brown, almost blackish spines and guard hairs which are tipped either with ochraceous-tawny or a dark brownish black. The sides are a pale russet, underparts white; under fur along sides light to dark gray; feet pale silvery drab with conspicuous white tufts at bases of claws; the under surfaces of the forelimbs are white.

Skull.—Much like that of *panamensis*, but with a proportionately narrow rostrum, especially noticeable in the middle; interorbital breadth less, the posterior part of the frontals consequently appearing laterally expanded; occipital region slightly narrower proportionately than in *panamensis*; interpterygoid fossa narrower, the angle being smaller. The skulls of fully adult animals are extraordinarily rugose, the frontals often containing deep pits, and the sutures between the nasals and premaxilla being much sunken.

Remarks.—The Azuero spiny rat—called macangué here as elsewhere in Panama by the natives—is an abundant species. The number we took was limited only by our supply of rat traps. The number of these instruments in our possession became smaller and smaller as the expedition progressed, owing to the irresistable appeal these articles had for our native porters. Each group of Indians, as they

[167]Ridgway, Color Standards and Color Nomenclature, 1912, Washington, D. C.

left us, appropriated a few traps, as these appeared to be the only means they had ever seen of effectively ridding their huts of rodents. A variety of baits were used by us successfully in trapping *Proechimys*—dates, raisins, dried prunes, bananas and rolled oats served equally well. Meat was not taken, but I was able to attract them with two species of insects—a large cicada and a huge green katydid. They readily entered steel traps set around fallen logs in the forest. One was taken in a tree.

Of the fifteen individuals taken, three were "bob-tailed", which proportion corresponds pretty well with figures reported by Enders[168] for the form *panamensis*. One steel-trapped specimen had evidently thrashed about until the skin at the base of the tail was completely ruptured. The flat-faced vertebrae then parted at the merest touch when the animal was picked up.

Nearly all were found to be badly infested about the neck, inner surfaces of the legs, groin, and ears, by those scourges of Panamanian field endeavor, redbugs. In some cases the massing of these small parasites was so extensive as to cause a distinct reddish appearance of the surface of the skin. They evidently caused these animals great annoyance as the areas were usually scarred and cut by scratching. I noticed that the redbugs apparently did not, or perhaps had not imbedded themselves in the skin, but were conducting operations from the surface. On ourselves they invariably "dug in". Perhaps, in a thin-skinned mammal like these octodonts, they are able to play the role of the larger but no less familiar ticks.

Mention is made above of a specimen (C.M.N.H. No. 1130) that, caught in a steel trap, had nearly accomplished the losing of its tail. The circumstances indicate that this animal, while trapped, had been attacked by some blood-sucking mammal, as it had a circular hole between the shoulder-blades through which it had bled profusely. Although alive when I found it, the animal was completely unconscious. If the attacker was a weasel, an animal we could find no evidence of in the vicinity, the spiny rat would certainly have been killed, but might have thrashed about considerably at first. I conclude that the guilty species was probably a vampire bat, individuals of which were fairly abundant in the region. The fact

[168]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 458.

that the animal bled continuously after the attack further supports this conclusion. The rupture of the skin of the rat's tail must have occurred as soon as it was trapped, as the bat would have been unlikely to have attacked a violently agitated subject.

No evidence as to their breeding habits was obtained, as only two females were secured and neither was pregnant. The smaller of the two looked, however, as if she might have been nursing young some time rather near to the date of her capture, (February 14th). This is somewhat earlier than the nursing period reported by Enders[169] for the form *panamensis*.

Proechimys is occasionally eaten by the natives, and although we tried none ourselves, the flesh has been reported excellent.[170]

Spiny rats were taken up to an elevation of about 2200 feet on the mountains, but none was captured at the highest camp, (Cavulla, 3000 feet) where the vegetation showed many upper tropical characteristics.

The present race is closer to the animal of Chiriqui, described by Thomas as a distinct form,[171] than it is to typical *panamensis* from the Canal Zone.

Considerable variation is present in my series, but in only one are the colors light enough on the sides to warrant confusion with the northwestern (Chiriqui) form. It is quite likely that specimens from the region in which we collected are partly intermediate between *panamensis* and a uniformly larger and darker animal living in the rich, rainy woods south of the Mariato River, toward Cape Mariato.

In the specimens of *panamnesis* that I have seen, which have come from Chiriqui and the Canal Zone, the white of the under parts, if present at all on the inner and under surfaces of the fore-limbs, occurs as a narrow white line about an eighth of an inch wide or less. In all but one of the specimens of *goldmani* at hand, this white line is widened to completely cover the inner and under surface of the fore-limbs. This is the only very distinctive divergence in coloring from *panamensis*, by which a single specimen may usually be determined. However, in series, the Azuero race is noticeably duller

[169]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 459.
[170]Allen, G. M., and Barbour, Bull. Mus. Comp. Zool., Vol. LXV, No. 8, 1923, p. 264.
[171]Ann. Mag. Nat. Hist., Series 7, Vol. 5, 1900, p. 220.

in the coloration of the sides than Chiriqui *panamensis* and has less ochraceous on the flanks and back. This race is further distinguished by certain cranial characters, namely the slenderer central portion of the rostrum, narrower interorbital width, and much more sharply recurved incisors. These characters are all much more noticeable when comparison is made between *goldmani* and typical *panamensis* from the Canal Zone.

It seems fitting that this form be named after Major E. A. Goldman whose "Mammals of Panama" remains the standard reference of Panamanian mammalogy.

Specimens Obtained.—Paracoté, 7; Mariato Rubber Camp, 6; Altos Cacao, 1; Cerro Viejo, 1.

Measurements:—

C. M. N. H. Number	Sex	Length	Tail	Hindfoot	Greatest Length of Skull (Occipitonasal)	Zygomatic Breadth	Mastoid Width	Interorbital Constriction	Length of Nasals	Maxillary Toothrow (crowns)
1251	♂	(229)		53	55.7	26.6	20.5	12.6	20.3	9.0
1184	♂	405	167	54	60.5	28.5		13.8	22.7	8.7
1191 Type	♂	395	155	52	56.8	28.1	22.3	12.6	21.1	8.8
1162	♂	375	150	51		27.6		13.1	21.1	9.0
1196	♂	385	158	54	58.4		21.5	12.8	22.0	9.1
1130	♂	353	150	51	53.5	25.7	20.6	12.5	19.6	8.5
1255	♂	(235)		53	57.1	27.0	21.2	12.8	21.8	8.6
1214	♂	410	170	54		29.0		13.8	22.8	9.1
1179	♂	(242)		56	61.7	28.6	22.4	13.7	22.7	9.1
1135	♂	353	144	51						
Average (Males)		382.3	156.3	53.9	57.7	27.6	21.4	13.1	21.6	8.9
1180	♀	352	142	51		27.0		12.3	19.2	8.8
1154	♀	310	131	46						

N. B. The numbers in parentheses refer to tail-less individuals.

Dasyprocta punctata pallidiventris ssp. nov. PALE-BELLIED AGOUTI.

Type Locality.—Paracoté (Plantation headquarters of the Boston-Panama Cocoanut Company), 1½ miles south of the mouth of the Angulo River, Mariato -Suay Lands, Veraguas Province, Panama. (Altitude: Sea level.)

Type.—Spec. No. 1226, young adult female, Cleveland Museum of Natural History; collected by Ignacio Alvarado, March 21, 1932. Field Number, B-A 105.

Geographic Distribution.—Known only from the type locality, and presumably confined to the southern tip of Veraguas.

General Characters.—A dark-rumped, narrow-skulled agouti with pale under parts and pale lemon yellow or straw-colored annulations on the hairs of the back, sides and shoulders.

Color.—Prevailing color of the upper parts dark brown, much darker on the rump than on the neck and shoulders, the hairs nearest warm-sepia[172] with straw-colored annulations or tips. The width of the light-colored bands on the individual hairs becomes steadily less from neck to rump, and the light color becomes invaded by the dark. Basal annulations are irregularly present on the rump-hairs, which are either very narrowly tipped with the palest straw or are sepia to the ends; sides brighter, the light tips and annulations nearly lemon-yellow and more extensive than on back and head; feet same color as rump; fore-legs and outer surfaces of hind-legs like sides; inner surfaces of hind-legs like rump.

Skull.—Much narrower in all proportions than that of *isthmica* or *dariensis;* rostrum not nearly so massive or deep as in these forms; premaxillae almost excluded from contact with the frontals, meeting them over an area of less than 2 mm.; lacrimal fronting widely on the antorbital foramen; nasals more sharply truncated posteriorly than in *isthmica;* angle of the mandible weak and dentition of lower jaw much smaller than in other forms from this region.

Measurements.—The type: Length, 507 mm; tail, 13; hindfoot, 119. Skull: Occipitonasal length, 103; zygomatic breadth, 44.9; inter-

[172]Ridgway, Color Standards and Color Nomenclature. 1912, Washington.

orbital constriction, 28.9; mastoid breadth, 30.8; least depth of rostrum, 22.1; width of rostrum (at least depth), 17; length of nasals, 37.7; maxillary toothrow (alveolar), 18.1; width of premaxillae at contact with frontals, 1.5 mm.

Remarks.—The lone individual at hand seems sufficiently different from other Panama agoutis to merit recognition as the type of a new race. One would expect the black-naped agouti (*D. punctata nuchalis* Goldman) to be the form found in the Mariato River district, but such is apparently not the case, as the color-scheme of *nuchalis* as reported by Goldman[173] is almost directly opposite to that of the present race. From *isthmica* the Mariato animal seems distinct enough in its dark rump and contrasting colors of the upper parts, while from *dariensis* it differs in numerous cranial details and paler sides and shoulders. From *Dasyprocta callida* Bangs from San Miguel Island *pallidiventris* is easily separable on the basis of the latter's dark rump, and yellowish back and sides, while from *coibae* it differs in a much narrower skull and lack of the conspicuous barring of the long hairs on the rump. While the narrowness of skull of the present form might conceivably be emphasized by the age of the specimen, the essential characteristics are so extreme that they are not shared by immature specimens of *isthmica* or by young adults of that race. I was able to see several other agoutis besides that one secured at fairly close range and all were noticeably dark-rumped and pale-shouldered.

Agoutis were common about Paracoté and were active at all hours, even at high noon on burning hot, sunny days. As they were quite regularly hunted by the natives they were very shy, and if seen at close range hesitated only for an instant before slipping into dense cover. As is so often the case, I had my best look at one when I was without a gun. While returning to the plantation one day from a trap-line, I stopped under a mango tree, cool as if air-conditioned, for a brief rest. While standing there I saw an agouti emerge from the thick brush beside the cart road about twenty feet away and sit down, rabbit-like, in the dust of one of the cart tracks. The animal looked at me very intently, lowering its head once or twice as if for a better look; it seemed to be thoroughly at home in the broiling noon-day sun and disappeared only when I moved incautiously.

[173]Proc. Biol. Soc. Washington., Vol. 30., 1917, pp. 113-116.

Where the agoutis make their burrows I was unable to discover with certainty, although the deep recesses among the roots of the giant creek-bottom figs were often thoroughly trampled by these animals. There are no ledges or rocky cliffs in the immediate vicinity of Paracoté. They may burrow in the thick brush that speedily overgrows abandoned cocoanut plantations.

We did not run across agoutis—"nequis" to the natives—in the mountains.

Coendou sp. PREHENSILE-TAILED PORCUPINE.

Spines found in the hide of a big king vulture (*Sarcorhamphus*) constitute the only direct evidence we found of porcupines. Two species are found in Panama, *Coendou rothschildi* and the somewhat rarer form *C. mexicanum laenatum*.[174] Mr. Davies said he had seen them on the peninsula in earlier years, but was of course unable to identify the species. King vultures are capable of extended flights and the presence of spines in their skins is in no sense proof that they were from the Azuero Peninsula; however, this was very likely the case.

Sylvilagus gabbi ssp. FOREST RABBIT.

Rabbits were common but wary at Paracoté, the only station at which we found evidence of them. Three or four customarily fed along the edge of the "port" and beach roads, and on one occasion I caught just a glimpse of one of these as it ducked into weedy cover. They left their tracks nightly in the dust, but occasionally were abroad during the day as well. One individual made a nuisance of himself along a mousetrap line I was running in a ditch. The fleeting impression I retain of the animal I saw is that in coloring it was somewhat more reddish than our Ohio cottontail, lacks white on the under surface of the tail, and has remarkably short ears. Their tracks were much smaller than those made by northern cottontails, if all I saw were made by adults.

Rabbits would have been very welcome accessions to our collection from the region, as the Mariato River is somewhat intermediate between the ranges of the subspecies *gabbi* and *consobrinus*.

[174]See Goldman, Smithsonian Misc. Coll., Vol. 69, No. 5, 1920, pp. 113-35; also Thomas, Nov. Zoöl., Vol. 10, April, 1903, pp. 39-42.

Dasypus novemcinctus ssp. NINE-BANDED ARMADILLO.

While we encountered no sign of armadillos during our stay in the district under consideration, Mr. Pinkney Davies assures me that they were occasionally seen in the region. The country would seem to be preeminently suited to their needs, and no barriers exist for them between the main cordillera and the Azuero Peninsula. From descriptions, only the nine-banded species appears to be known in the region. We could garner no evidence of *Cabassous*.

Tamanduas tetradactla chiriquensis Allen. CHIRIQUI THREE-TOED ANTEATER.

On the last day of our second stay at Paracoté I took one final walk along one of the trails that the natives had cut for our use—the one that passed through the mequinque palm bottoms northwest of the plantation. I followed this to its extremity, and while standing perfectly still in midtrail, noticed a rustling of leaves, as of an animal walking. A tamandua appeared shortly and when it got to within forty feet of me, I fired at it with the .410 barrel of my game-getter, using No. 5 shot. Subsequent examination revealed that not one shot had penetrated the hide. Instead, it knocked the animal down and frightened it into immediate flight which instead of being overland, was by way of a crinkly liana that stretched from the ground to the crown of the forest, about a hundred feet overhead. The animal went up the liana with the speed of a monkey—I had barely time to put my one remaining shell, a .22 long, into the .22 barrel, aim and fire. The anteater had reached the lowermost level of the forest crown. My shot broke the unfortunate creature's back and it fell to the ground, but without being further incapacitated. It immediately braced itself, and I was faced with a dilemma. I stepped on the animal to put it out of its misery, and forthwith learned another lesson from the big book of experience. The anteater seized one of my shoes with one paw, gave a squeeze and drove her huge talons clear through the heavy leather sole! By the purest accident the claws went between my toes and not into them.

The stomach of this specimen was nearly empty, but contained a few remains of termites.

These animals are apparently fairly numerous as the natives were thoroughly familiar with them, and evidence of their diggings were frequently noted, especially in the vicinity of the Mariato Rubber Camp.

Pecari angulatus crusniger (Bangs). CHIRIQUI COLLARED PECCARY.

Collared peccaries are among the mammals more commonly seen at Paracoté. On one of my first visits to my trapline along the "port" road, I was attracted by a slight noise in the ditch behind me. Turning, I made out the forms of forty or fifty zahinos within a stone's throw, just standing or moving very quietly among each other, their fingers obscured by brush and broken patches of early morning sunlight filtering through the leafy crown overhead. They had not crossed the road, yet the nearest was only fifteen feet from me. If they had, my trapline would have fared badly. Although I was armed with a 30-30, a lot of peccary stories flashed to my mind and I didn't shoot. Local advice subsequently proved to be that although the herds near the plantation were much hunted and fearful of man, it was well not to kill one when you are practically in the middle of the flock. Familiarity apparently breeds contempt. One of this drove was subsequently collected at night.

At our Cerro Viejo station at 2200 feet, Mr. Aldrich entertained callars in the form of this species one afternoon while he was skinning birds. They came through camp, minding their own business, while he stuck strictly to his.

I have not compared the specimen we obtained to other peccaries and it may prove to be the Canal Zone *bangsi*. Its dark color and tawny shoulder stripes are, however, characteristic of *crusniger*. It was taken on March 28, 1932 at Paracoté, Mariato-Suay Lands, Veraguas.

Tayassu pecari spiradens Goldman. COSTA RICAN WHITE-LIPPED PECCARY.

This species is the "puerco del monte" of the Azuero natives, and is distinguished from the "puerco grande" or razorback hog and

the "zahino" or collared peccary. Like the other pigs, the white-lipped peccary has been much hunted and is said to be much afraid of man. Mr. Davies reported that in the wilder districts southwards towards Cerro Hoya and the Arenas River they are less accustomed to hunters and are dangerous. We found no certain traces of them in the course of our trip.

Sus scrofa ssp. RAZORBACK HOG.

Razorback hogs have been at large on the Azuero Peninsula for a long, long time, perhaps for several hundred years. The time when they were a disturbing new element has long since past and they are now part and parcel of the natural scheme of things, food supply of big cats and man, rooters-up of the mountain slopes. They are, according to Mr. Davies, locally abundant. I myself saw them but once, on March 14 at about 10 A. M., when with glasses I watched three crossing a grassy ridge between two points of ravine-bottom woods at an elevation of about 3100 feet near Cavulla.

Odocoileus chiriquensis Allen. PANAMA WHITE-TAILED DEER.

The Panama white-tailed deer is very abundant about the Mariato drainage, yet circumstances were such that the writer got only one long-range shot at one, which went wide of its mark. On certain mornings when I did not want to carry my gun in addition to heavy bags of traps, I would be sure to see three or four; while organized deer-hunts by me and our men were entirely unproductive. I somehow could not bring myself to collect the little spotted fawn that was part and parcel of the plantation's compound menagerie.

In the heaviest brush these deer would permit a close approach—occasionally to within a hundred feet before they would bound off stiff-legged and "barking" in a manner identical to their northern relatives. In fact, all their habits seemed to be entirely typical of the Virginia deer. The little fawn of our plantation door-yards browsed on most of the trees of the compound and like the big green iguanas, was very fond of hibiscus blossoms. I watched him take quick bites of *Mimosa* leaves, and he never took two bites in the same place as each fat thorn of these plants was inhabited by

a tiny agile wingless bee, incredibly authoritative for its size; besides, every surviving frond of leaves on any one branch "collapsed" after being shaken!

Deer were seen at all our camps and on several of the marches. On the high llanos about Cavulla they were excessively wary, and gauged to a nicety the distance necessary for safety between themselves and a man. Those on the ridge I happened to be on would vanish in front of me, while those 500 yards away, on the next ridge across a deep, wooded draw, would stay out in plain view watching me. On these llanos they repaired to the sunniest slopes in the early mornings, just as their lowland brethern took similarly to the open spots in the plantations. As in the low country, they were presistently hunted by natives, at all seasons.

These deer are said to be smaller on the average than the Virginia deer, but we saw some very impressive big stags with excellent heads. In a country teeming with every conceivable arthropod parasite, these heads should be reasonably safe from sportsmen for some time.

The deer had apparently begun to shed their horns by the middle of February, as no males with horns were seen after that date. One male with new velvet was observed on April 3, the new horns being only three or four inches long. Enders [175]reports that a captive animal at Barro Colorado first grew horns in April.

Odocoileus is the only deer of the region here considered, as *Mazama*, the brocket, is entirely unknown both to white and Indian hunters.

[175]Bull. Mus. Comp. Zoöl., Vol. LXXVIII, No. 4, October, 1935, p. 482.

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THE DORSAL SPINE OF *CLADOSELACHE*

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THE NEUROCRANIUM AND JAWS OF *CLADOSELACHE*

1938

By
John Edward Harris, Ph. D.

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1. THE DORSAL SPINE OF CLADOSELACHE

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Cladoselache has always been considered to be a form which possesses no fin spines or armouring of any kind. Eastman (1907), it is true, makes an obscure reference to the fact that Dean had discovered traces of such armour, but as Dean himself in his later memoir (1909) does not mention the topic, it becomes difficult to explain Eastman's remark. The absence of spines has been regarded by many authors as indications that *Cladoselache* is a primitive form; recently, however, Gregory (1936) has suggested that the possession of such spines is a primitive feature in shark organization, and that the absence of them in *Cladoselache* indicates that this form is to be regarded as more advanced than *Ctenacanthus*.

It was with some interest that the present writer, in examining a large collection of *Cladoselache* specimens in the Cleveland Museum of Natural History, noted the presence of an undoubted spine in the region of the first dorsal fin of this genus. The existence of this spine is well established by the specimens in the collection, since in two cases the spine has been found in its natural position on the body of the shark, while in seven or eight other specimens the detached spine is found associated with portions of neurocranium, jaws or pectoral fin.

The best spine in the collection (C.M.N.H. 5678) is illustrated in figures 1 and 2, and in the photographs of Plate I. It was found in its natural position, almost perpendicular to the body surface of a large *Cladoselache* (*sp. ? fyleri*). The species is given with some hesitation, since from the size of the pectoral fins the shark must have been over two meters in length, far larger than any previously known specimen of *C. fyleri*. Only the head and anterior part of the body are at present available for study, and the shape and structure of the pectoral fins agree more closely with *C.fyleri* than with *C.kepleri*. The only other possibility (apart from that of a new species) is that the

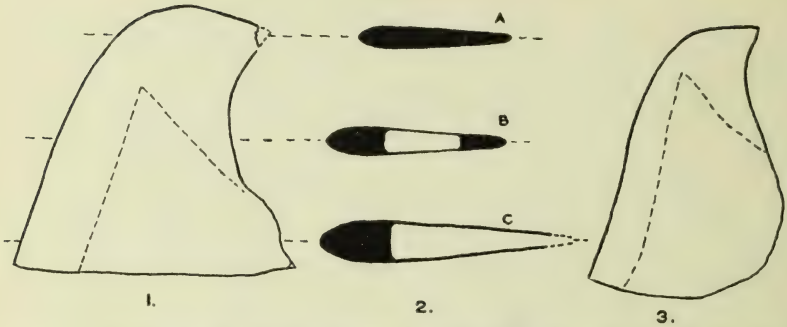

FIG. 1. DIAGRAM OF THE DORSAL SPINE OF *Cladoselache* (*?fyleri*) SEEN FROM THE LEFT SIDE. The dotted line marks the boundary of the hollow part of the spine. A small portion at the extreme tip is missing.

FIG. 2. CROSS SECTIONS THROUGH THE (RESTORED) SPINE OF *C. fyleri*. The levels are indicated by the dotted lines which cross Figure 1 at the corresponding heights.

FIG. 3. THE DORSAL SPINE OF *Cladoselache kepleri*.

fish is *C.clarki*, and this seems to be ruled out by the pectoral fin ray formula, as there are 20 primaries, 10 secondaries and 4 tertiaries. It must be admitted, however, that the taxonomy of this genus is in an extremely unsatisfactory state. Dean's (1909) species characteristics, whether taken singly or in combination, have been found absolutely unreliable when applied to some of the best specimens in the Cleveland collection. A complete revision of the genus is needed.

The height of the spine is only about 8 centimeters, and as the figures show, its length along the body axis is almost as great. At its broadest point, near the base, it is about 8 millimeters in thickness, so that in shape and size it differs very markedly from the anterior dorsal fin spine of *Ctenacanthus*. Horizontal sections of the spine at three different heights above the base are shown in figure 2. The anterior border, and the whole of the upper portion are solid, but in the lower part, the posterior region is a hollow structure. Pressure has caused the surface over this hollow region to collapse on one side of the spine, as is clearly shown by the photographs.

The surface of the spine is traversed by numerous grooves, but though the texture of the material is similar to that of the *Ctenacanthus* spine, the grooves are not arranged in a regular and parallel manner, and there is no evidence of ornamentation. It is important to note that in this and in all the other spines found, there is no trace of a basal portion sunk below the skin surface. The absence of this characteristic suggests that, unlike the spine of *Ctenacanthus*, this spine must have been rather loosely anchored to the body, which may explain its absence from all previously described specimens.

PLATE I. THE DORSAL SPINE OF *Cladoselache (?fyleri)* PHOTOGRAPHED FROM THE LEFT AND RIGHT SIDES.
On one side the surface above the hollow portion of the spine has been crushed in, showing clearly the boundary of the cavity. There is no basal (internal) portion to the spine; the projection seen at the lower part of the right hand photograph is matrix, and lies more or less perpendicular to the plane of the spines.

Specimen C.M.N.H. 5047 also possesses a dorsal spine in the natural position, but only the basal portion of the spine is preserved. Though the length of this shark (which is almost complete, and in an excellent state of preservation) is 145 centimeters to the base of the tail, its general characteristics agree with those of *C. fyleri* rather than with those of *C. kepleri*.

In both C.M.N.H. 5047 and C.M.N.H. 5678 the anterior border of the spine is situated just in front of the anterior border of the pectoral fins.

In about seven or eight other specimens of *Cladoselache* in the Cleveland collection, a similar spine is found, frequently associated with fragments of the pectoral fin, occasionally with jaws and neurocranium. In one such specimen, the pectoral fin is very similar to that of *C. kepleri*, and the spine is distinctly different in shape from those described above. Such a spine, from C.M.N.H. 5420, is illustrated in figure 3. It is significantly higher relative to its basal length than that of C.M.N.H.5678, and the solid portion occupies a smaller area of the spine. The general structure of the spines, and the appearance of the striations, are in other respects similar in all the specimens.

Many other specimens of *Cladoselache* are seen to have a slight protruberance near the mid-dorsal line between the insertion of the pectoral fins. This is almost certainly the indication of the existence of the spine in the matrix beneath the body; it was from such a specimen that the spine of C.M.N.H. 5047 was excavated.

In *Ctenacanthus* and in the Hybodont sharks the dorsal spines form part of the fins, the anterior border of the fin membrane being closely applied to the grooved posterior surface of the spine. It might therefore be expected that the dorsal spine of *Cladoselache* was similarly related to the first dorsal fin. Nevertheless, a careful consideration of the structure and position of the spine would suggest that this is not the case, but that the anterior fin border was separated from the spine by some little distance. The reasons for this suggestion may be summarized as follows:

(a) The posterior surface of the fin spine in *Cladoselache* has no definite groove to receive the anterior border of the dorsal fin, as it has in *Ctenacanthus* and *Hybodus*.

(b) The shape of the posterior border of the spine, with its strongly curved outline, is such that it is difficult to imagine the shape and structure of a dorsal fin which could be applied to it.

(c) None of the previously known specimens which show the first dorsal fin appears to have had the spine in position. And in the two specimens from the Cleveland collection described above, the spine is present, but there is no trace of a dorsal fin associated with it.

(d) The spine is situated somewhat anterior to the position of the first dorsal fin, according to Dean's restoration.

(e) There is little or no basal portion to the spine. The fin spines of *Ctenacanthus*, *Hybodus*, &c. all possess a well marked unornamented portion which lies below the body surface, and which is frequently associated with a triangular basal plate on which rest the radials of the fin.

These considerations would lead one to suggest that the spine is merely an enlarged scale (or possibly a mass of fused scales) situated almost entirely on and external to the body surface. It is perhaps tempting to suggest that the central hollow portion is the pulp cavity of a single greatly enlarged scale.

Though the position and shape of the spine in *Cladoselache* is so different from that in *Ctenacanthus*, the structure of the spine in the former does not differ fundamentally from that of the spine in the latter. It may be recalled that *Ctenacanthus* possesses a spine which is hollowed out on the posterior surface by a deep groove. Along the lower portion of the spine this groove is open, and encloses the fin, but the upper part of the groove is covered over by a posterior ridge, more or less semicircular in cross section, which runs down from the tip of the spine for about half of its length. This ridge very probably represents the posterior solid region of the *Cladoselache* spine. The groove in *Ctenacanthus* would then correspond exactly to the hollow portion of the spine in *Cladoselache*; the difference between the two could be explained by the presence of the fin in *Ctenacanthus* preventing the closure of the groove in the lower part, at the same time not permitting any great extension of the spine base along the length of the body.* One might conceivably go a step farther. If the approximation of the spine to the dorsal fin is still closer, the antero-rosterior thickness of the spine would be still further reduced, and the spine would probably become shorter (in height). Passing through a Hybodont type of spine, a stage might thus be reached similar to that found in *Goodrichia* (Moy-Thomas, 1936), followed by the ultimate disappearance of the whole structure. This series is perhaps too highly speculative to be taken very seriously. At all events, the presence of the dorsal spine in *Cladoselache* and its definite homology with that of *Ctenacanthus* gives additional weight to Moy-Thomas' argument (*loc. cit.*) that the fishes *Cladoselache*, *Ctenacanthus* and *Hybodus* form a series showing increasing specialization. Gregory's hypothesis (1935) that *Cladoselache* is an advanced form becomes extremely unlikely.

* It is quite possible that the first dorsal fin of Cladoselache was inserted into the hollow of the spine for a very short distance above its base. The fossil spines are so compressed laterally that it is impossible to know whether the posterior border was totally closed in the lower portion. It has therefore been represented in the cross section in Fig. 2C by a dotted line.

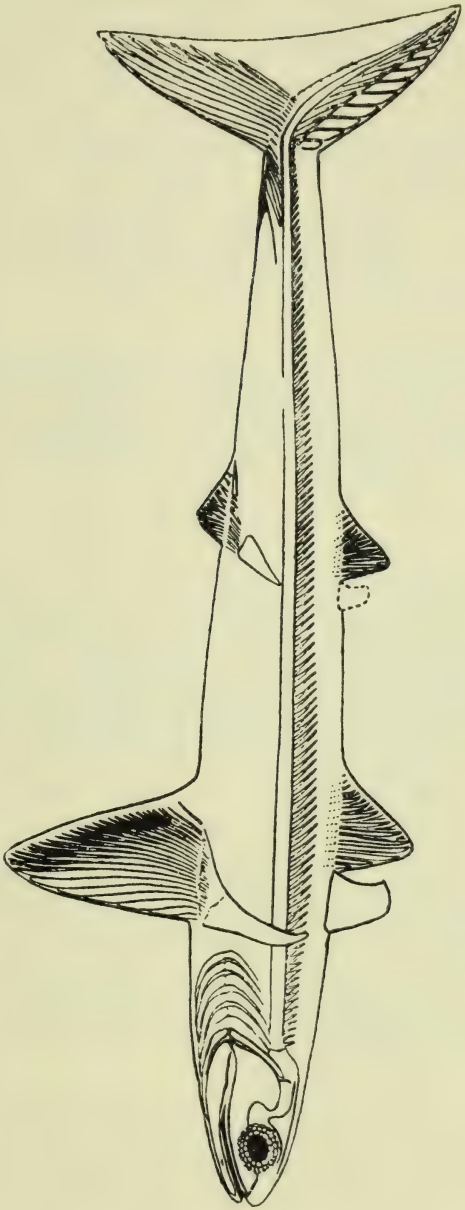

FIG. 4. A RESTORATION OF *Cladoselache fyleri*, MODIFIED FROM THAT OF DEAN (1909).

It would be interesting to know if a similar structure exists in front of the second dorsal fin of *Cladoselache*. Up to the present no such spine has been discovered, but it is hoped that the opportunity may arise for a more careful search through the material.

Though this is the first record of the dorsal spine known to the writer, it is perhaps interesting to note that in Dean's memoir (1909), in the photograph of a crushed skull of *Cladoselache kepleri* in Plate XXVII, there is a very obvious dorsal spine to be seen on the right hand side of the photograph. The original specimen confirms this interpretation, and also shows that the general form of the spine is the same as that in figure 3, which the writer had already ascribed to *C. kepleri*.

A restoration of *Cladoselache*, modified after that of Dean (1909), is shown in figure 4. In addition to the presence of the spines, changes have also been made in the shape of the dorsal fins, and the cranial region has also been slightly modified in accordance with the specimens described in the later communication.

SUMMARY

Two species of *Cladoselache* have been shown to possess a large spine, situated immediately in front of the first dorsal fin. The shape of the posterior border of the spine suggests that it could not have been so closely approximated to the fin as is the case in *Ctenacanthus*. It seems probable, however, that the spines in the two genera are homologous structures, that of *Cladoselache* showing a number of more primitive features. Such a hypothesis agrees with the generally accepted view that *Cladoselache* is the most primitive of all the known Cladodont sharks.

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2. THE NEUROCRANIUM AND JAWS OF CLADOSELACHE

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In the palaeontological collection of the Cleveland Museum of Natural History there are a number of specimens of *Cladoselache* showing portions of the neurocranium, jaws, dorsal spine (see previous note) and pectoral fin. Two of these specimens appear to be of sufficient interest to be described in a special note, as they increase considerably our knowledge of the morphology of the genus.

Specimen C.M.N.H. 6233 is undoubtedly the finest in the collection. It is illustrated in the drawing of fig. 1., and the portion of the block containing the neurocranium is shown in the photograph of Plate II. The neurocranium is seen in ventral view, and the specimen shows also the upper and lower jaws of both sides, traces of hyomandibular and ceratohyal on one side, and a well preserved dorsal spine. From the shape of the spine, the species represented is almost certainly *Cladoselache kepleri*. (see previous note.)

The ventral neurocranial surface of the specimen closely resembles that of *Cladodus wildungensis*, described and figured by Stensio (1937), and the general resemblance to the neurocrania of *Chlamydoselachus*, *Heptanchus* and other primitive modern sharks is equally striking. The ethmoidal region is lacking, as it is in Stensio's specimen, and the general appearance suggests that this region was relatively thin and delicate, in contrast to the heavier posterior portion of the skull. The occipital region is preserved complete, but is largely covered by the left palatoquadrate cartilage, which is seen from its inner side.

The post orbital process is long, as in *Cladodus;* but instead of turning sharply forwards at its distal end, it seems to be much straighter, and more or less perpendicular to the long axis of the cranium. The wall of the orbit has been crushed down almost to a

level with the ventral surface, so that the detailed outline of the shape of the post orbital process is not well shown. There is, however, no suggestion of an articular surface for the reception of an otic (quadrate) process of the palatoquadrate, in which respect the skull resembles that of *Cladodus* (Stensio, *loc. cit.*) and that of the modern *Chlamydoselachus* (see Allis, 1923).

The otic capsule is well preserved on the right side, showing a very strongly marked bulla acoustica. The occipital region posterior to the otic capsule differs somewhat from the restoration of Stensio in that the central portion, traversed by the foramen magnum, projects much farther posteriorly.

Several foramina are clearly visible on the neurocranial surface. The paired common carotid foramina (*c.c.*) are clearly shown, as are the openings (*p*) for the canals of the posterior branch of the r.palatinus VII. Anterior to these last, and slightly more mesially placed, are the paired foramina for the passage of the orbital (external carotid) arteries (*o.*). Unlike the neurocranium of *Cladodus*, the internal carotids apparently entered the brain through a single median foramen (*i.c.*), which may indicate that the neurocranium of *Cladoselache* had thinner walls than that of *Cladodus*. This is also suggested by the complete absence of any trace of superficial grooves traversed by the internal carotid and orbital arteries. Though both these differences (the thinness of the neurocranial wall and the single internal carotid foramen) might suggest that *Cladoselache* is slightly more advanced than *Cladodus*, they are probably too insignificant to carry much weight. Anterior to the internal carotid foramen in the mid-line is seen the fenestra hypophyseos (*f.hy.*).

The large foramen (*o.p.*) is visible on one side only of the specimen, though there is a small slit like depression at the corresponding position on the opposite side which may represent the same passage. From its position and its direction of penetration of the neurocranium, it may represent the common opening through which the orbital artery and the anterior r. palatinus VII enter the orbit. Since this foramen would lie on the lateral boundary of the ventral surface of the neurocranium, it might be well preserved on one side and closed on the other, due to a slight pressure asymmetry in preservation.

A large part of the orbital wall is preserved in this specimen, flattened down to a level with the ventral surface of the skull. Assuming that the flattening has not badly distorted the general proportions, the large area of this wall suggests that the eye of *Cladoselache* was protected by a large overhanging orbital roof.

An interesting feature of the specimen is the pair of pits which can be clearly seen in the photograph, just anterior to the post orbital process. The groove leading into them passes outwards and dorsally, so that it does not lead towards the cranial cavity. It might conceivably correspond to the numerous openings in *Chlamydoselachus* by which the r. buccalis VII communicates with the post-orbital latero-sensory canal. No other passages for the nerves to the sensory canals can be seen in the specimen, which would therefore differ very greatly from that of *Chlamydoselachus*.

The jaws of the specimen are similar to those of *Cladodus wildungensis*, described and figured by Jaekel (1925). The quadrate (otic) process of the palatoquadrate, though greatly expanded, shows no trace of an articulation with the post orbital process of the neurocranium, and presumably served only for the origin of a large adductor mandibularis muscle. The orbital process (*pr.*) is not strongly developed, as in recent forms.

The presence of the tooth grooves on the outer surface of the right palatoquadrate indicate that there were relatively few teeth —not more than eight or nine on each side. This would be expected from the large size of the teeth in Cladoselache.

The hyomandibula is not clearly seen in this specimen — it is probably represented by the small rudiment shown at *hm*. The right ceratohyal is visible as the fragment *r.ch*. It is very imperfectly seen in this specimen, but is well shown in the next specimen to be described. The dorsal spine, (*d.s.*) has already been dealt with in the preceding note.

C.M.N.H. 5769 is also a specimen of *Cladoselache kepleri*, showing a similar ventral view of the neurocranium, which, however, is not so well preserved in this specimen. The foramina on the ventral surface are identical with those of C.M.N.H. 6233. The distal parts of the two palatoquadrate cartilages are absent, but on the left side, the hyomandibular has been preserved in two pieces, as a thin rod like cartilage. The right ceratohyal is well shown, its lower border agreeing well with the contour of the right mandible.

Figure 3 represents a restoration of the skull of Cladoselache, seen in side view. The jaws etc., have been fitted to the position of the skull by cutting out tracings from the actual photographs of the specimen. The restoration has been completed with a relatively short rostrum, making the mouth sub-terminal rather than ventral. This would seem to agree best with the extremely long mandible. The general resemblance to the head of Chlamydoselachus is seen to be extremely close.

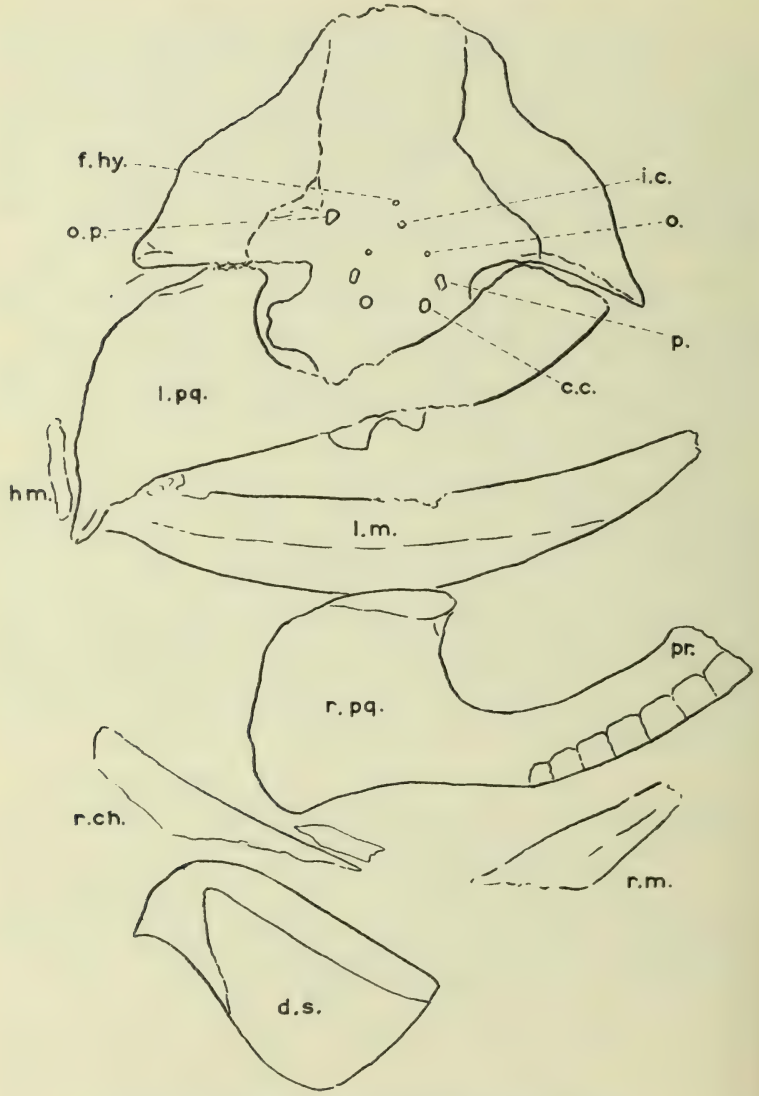

FIG. 1. DIAGRAM OF C.M.N.H. 6233. *Cladoselache kepleri*.

c.c.: common carotid foramen; *d.s.*, dorsal spine; *f.hy.*, fenestra hypophyseos; *hm.*, ?hyomandibular; *i.c.*, internal carotid foramen; *l.m.*, left mandible; *l.pq.*, left palatoquadrate; *o.*, orbital (external carotid) foramen; *o.p.*, foramen for exit of orbital artery and of the anterior ramus of pal. VII.; *p.*, foramen for posterior r. pal. VII.; *pr.*, orbital process of palatoquadrate; *r.ch.*, right ceratohyal (?); *r.m.*, right mandible; *r.pq.*, right palatoquadrate, showing tooth grooves in distal portion.

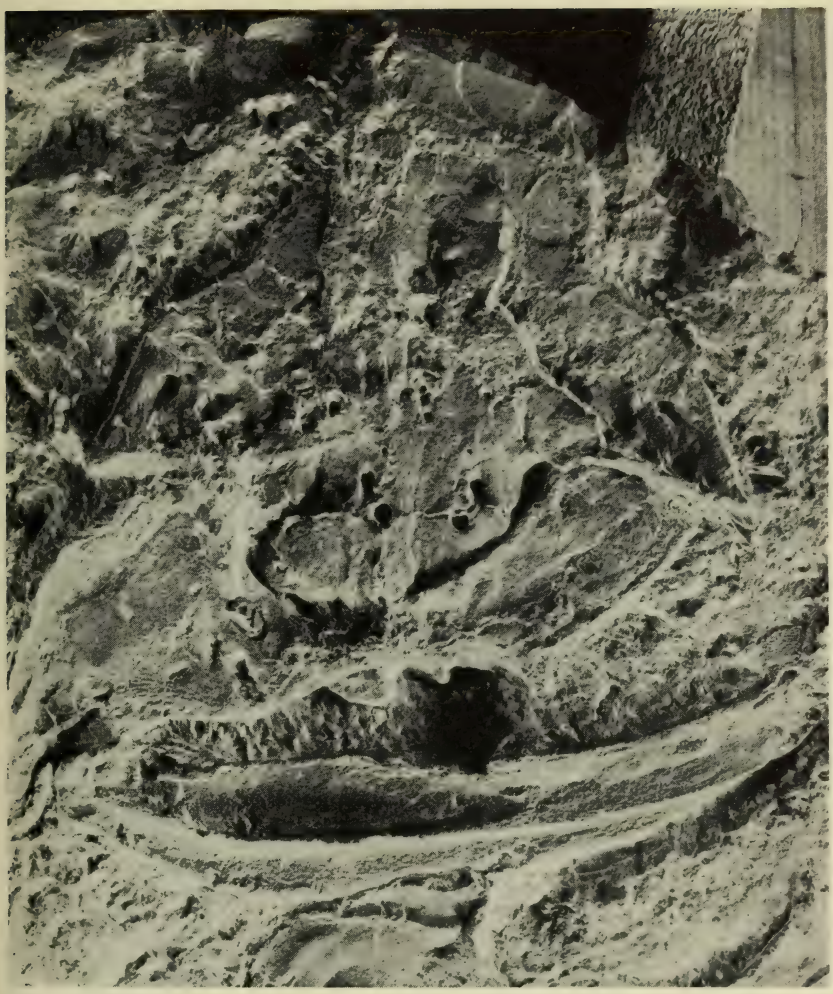

Plate II. Photograph of Part of Specimen C.M.N.H. 6233, Showing the Neurocranium and the Upper and Lower Jaws of One Side. The relationship between the post orbital process and the palatoquadrate is accidental, as the jaws are those of the left side.

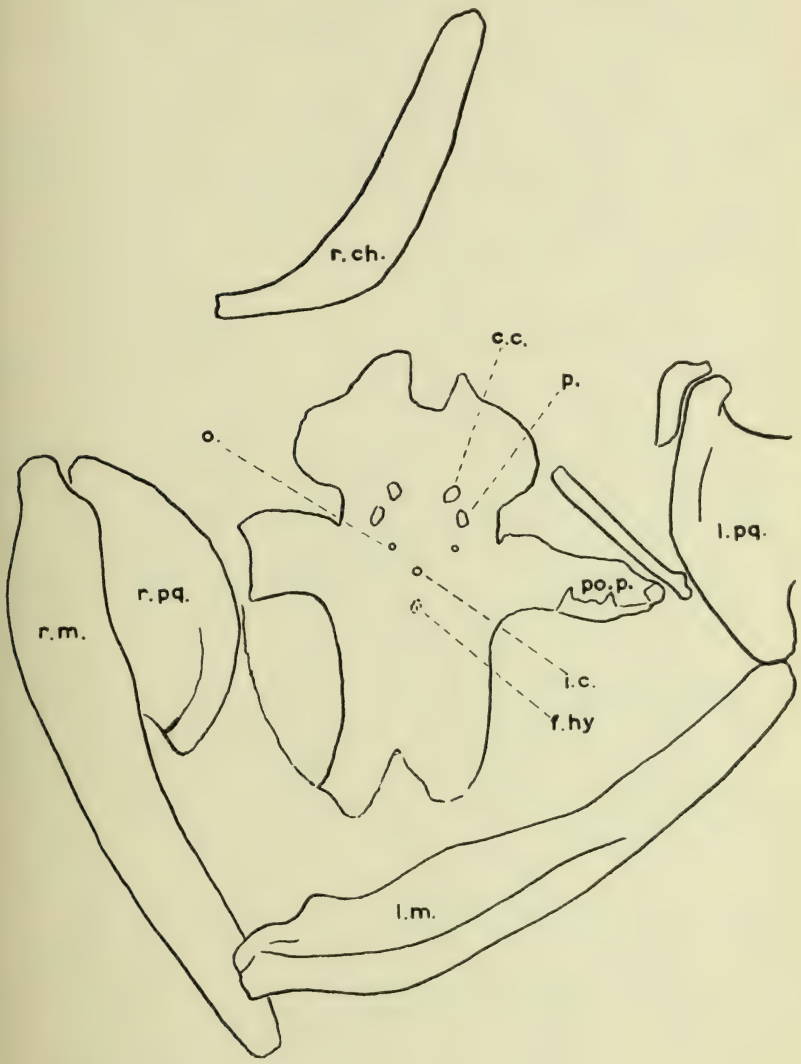

FIG. 2. DIAGRAM OF C.M.N.H. 5769. *Cladoselache kepleri*. *po.p.*, post orbital process. Other lettering as in FIG. 1.

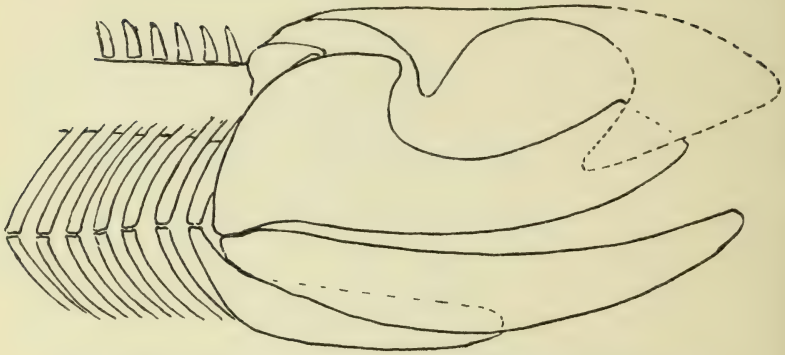

FIG. 3. RESTORATION OF THE HEAD OF *Cladoselache kepleri* IN LATERAL VIEW.

SUMMARY

A description is given of two neurocrania, with their associated mandibular and hyoid arches, of *Cladoselache kepleri*. Apart from slight differences in shape, and the possession of a single internal carotid foramen, the neurocrania agree very closely with that of *Cladodus wildungensis*, as dercribed by Stensio. A reconstruction of the skull suggests that the mouth was sub-terminal, and that the general appearance of *Cladoselache*, as well as its anatomy, would strikingly resemble that of *Chlamydoselachus*.

I am greatly indebted to Mr. H. L. Madison, the Director of the Cleveland Museum of Natural History, for his kindness in allowing me to work on the collection, and for the facilities he provided during my stay in Cleveland. It is a pleasure also to acknowledge the unfailing courtesy and assistance of Mr. P. A. Bungart, who was originally responsible for the collection and preparation of the specimens described.

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A NEW ARTHRODIRE

FROM THE

CLEVELAND SHALE FORMATION

By
David H. Dunkle
and
Peter A. Bungart

SCIENTIFIC PUBLICATIONS
OF THE
CLEVELAND MUSEUM OF NATURAL HISTORY
Vol. VIII, No. 2, pp. 13-28
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PLATE III

Gymnotrachelus hydei (CMNH. Cat. Fos. Fishes No. 5724). Photograph of the shale block containing the greater part of the type specimen. For an explanation see Text Fig. 1. Slightly less than x 3/10.

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SCIENTIFIC PUBLICATIONS
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A NEW ARTHRODIRE FROM THE CLEVELAND SHALE FORMATION

BY
DAVID H. DUNKLE AND PETER A. BUNGART

INTRODUCTION

The Cleveland Museum of Natural History possesses a collection of fossil fishes numbering some two thousand and two hundred specimens. The collection is comprised of Arthrodiran, shark and Osteichthyian remains collected, during the past seventeen years, exclusively from the exposures of the Upper Devonian Ohio Shales occurring in Cuyahoga, Lorain, Erie, and Huron Counties, Ohio. It is undoubtedly the largest single collection of these fishes from the Devonian of Ohio which has ever been accumulated. Its importance is further enhanced by the facts that nearly all of the known forms from these rocks are represented, and that, in a number of cases, genera are represented by large series of specimens. The collection offers a means, therefore, toward the solution of various taxonomic and phylogenetic problems concerning these early fish groups hitherto only partially answered.

As the initial step in a proposed comprehensive study, a survey of the entire collection has been made. During this rather cursory examination, a number of specimens were observed which we consider belonging to previously unrecognized forms. It has been thought best to describe these new fish separately as time permits. The present paper concerns the remains of a small Arthrodire recovered by one of us (P. A. B.) from fallen shale debris. The specimen consists of a number of bones and impressions of bones displayed in a shale slab, and also several free plates. The series of bones, from the head shield and body carapace, is not complete. Most of the plates are easily identifiable, despite complete disassociation, by comparison with those of other Arthrodires. There is no doubt but that the entire assemblage of bones is from a single individual.

We wish here to express our grateful appreciation to Mr. Guerdon S. Holden of Cleveland for his kindly interest in this work. Mrs. J. E. Hyde and Mr. Eber Hyde have been most considerate in placing at our disposal the library and notes of the late Professor Jesse Earl Hyde, Curator of Geology at The Cleveland Museum of Natural History from 1922 until 1936, in whose honor the species is named.

Gymnotrachelus hydei gen. et sp. n.

Type Specimen. C. M. N. H. Cat. Fos. Fishes No. 5724: a number of disassociated bones and impressions of bones from the head and body armor contained in a shale slab; also several loose bones from the same individual.

Geological Horizon and Locality. Cleveland Shale Formation of the Upper Devonian on Townnes Creek, (Oberlin Quadrangle) Lorain County, Ohio.

Collected — May 7th, 1928 by Peter A. Bungart.

Generic Diagnosis. A comparatively small Arthrodire with broad and somewhat flattened head shield and body carapace. Bones relatively heavy in proportion to the size of the fish, unornamented, and widely overlapping in their contact with each other. Orbits large and forwardly placed; limited in front by a strongly developed preorbital process; post-orbital process quite indistinct. Dorsal unarmored space between the Median Basal and Median Dorsal nearly twice as long as wide between the condyles on the Antero-dorsolaterals. Median Basal broader than long; the postero-lateral processes converging forward in approximately a ninety degree angle; postero-median spine stout. Externo-basal widely overlapped along most of its dorsal margin by the Median Basal; condylar fossa broad and shallow; the glenoid process represented by a weakly developed protuberance. The anterior portion of the Sub-orbital heavy; lateral face of this portion much deepened; as long or longer than the thin expanded posterior portion. The Antero-supra-gnathal roughly triangular and plate-like; a single series of tooth-like tubercles projecting down from the anterior and lateral margins. Postero-supragnathal long and slender; a single row of evenly spaced "teeth" project along the entire inferior border. Infero-gnathal long and

comparatively heavy; dorsal margin of the anterior half studded with "teeth" which may be in more than a single longitudinal row; presumably with no high anterior cusp developed.

Median Dorsal with a short median and a pair of long lateral anterior processes; ventral keel low and not extending to the anterior limits of the plate; posterior portion of the keel thickened and projecting beyond the rounded posterior margin of the dorsal plate. Antero-dorso-lateral deeper than long; condyle moderately developed; sub-glenoid process weak; anterior margin of the bone extended markedly upward and backward dorsal to the condyle. The Antero-lateral short but indicated to be exceedingly deep.

Sensory canals developed as deep narrow grooves. The externo-basal canal represented by a single pit immediately anterior to the lateral extremity of the condylar fossa. An accessory central canal present. Gape between dorsal and ventral portions of the sub-post-orbital canal wide. Gnathal and sub-post-orbital canals not joined on the sub-orbital plate. Antero-lateral canal not developed on the Postero-dorso-lateral.

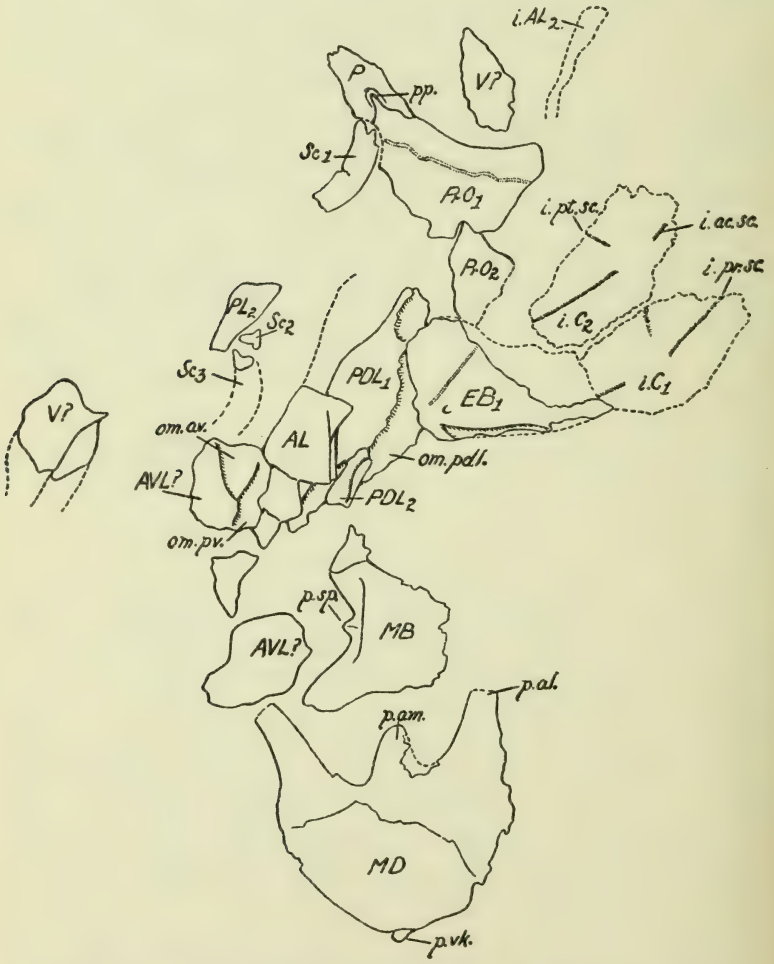
Specific Diagnosis. — At this time the same as the generic diagnosis.

DESCRIPTION

The bones and impressions of bones comprising the type specimen indicate an Arthrodire of small size. In contrast with this small size, the proportionately robust development of the bones is noteworthy. The preservation is generally excellent. Only a slight distortion of the elements by crushing has occurred, a fact due perhaps to the heavy deposits of pyrite laid down within the cell spaces. The external and internal surfaces of the bones do not exhibit any ornamentation and even the radiating lines of ossification are but faintly discernible. The areas of overlap by adjacent bones are exceedingly broad and well defined.

Bones of the Cranial Roof. — The Median Basal (MB) is preserved with the dorsal and posterior surfaces exposed for examination. The dorsal surface is gently convex from side to side. Its postero-lateral angles are drawn out into broad extensions which overlap much of

the dorsal edge of the Externo-basals. The greatest width of the Median Basal occurs across the extremities of these postero-lateral processes. The maximum length of the bone is only two-thirds this width. The posterior margin of the plate is thickened and encloses



TEXT FIG. 1. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). Outline sketch of Plate I, showing the arrangement of the disassociated bones and impressions on the shale block. Approx. x 3/10.

an indentation whose outline tapers to a forward angle of approximately ninety degrees. An exceptionally stout median spine projects backward into this indentation from the thickened posterior surface of the bone. The anterior border of the Median Basal is truncated and the width of this margin is less than half the posterior width.

The paired Centrals (C) are represented mainly by the impressions on the shale block of their ventral surfaces. Only small fragments of the actual bones remained, at the time when the specimen was discovered. These plates are large, twice as long as broad, and are indicated to have been of comparatively thin uniform thickness. Their margins are very irregular and appear serrated. As in the cases of many Arthrodires, the courses of the externally grooved sensory canals are marked by corresponding ridges on the internal surfaces of the bones. The presence of the pre-orbital canal, the so-called sub-post-orbital canal extension on the Central, and an accessory central canal, the middle head line of Stensio (1925), are clearly exhibited by the impressed ventral surfaces. The terminations of these canals are widely separated near the center of ossification.

The Pineal (P) is a small plate lying ventrally exposed. The bone tapers to a blunt point in its posterior portion. Anteriorly, although partially covered by the left Pre-orbital, it is quite broad. At about the center of the plate a pronounced elevation encloses the pituitary pit. The character of this elevation is reminiscent of that found in *Stenognathus* except that forward its sides do not appear to diverge as widely. The visible margins of the element surrounding this central structure are flat and thin. Their surfaces are marked by radiating ridges and grooves which indicate a firm overlap of the Pineal on the antero-mesial edges of the Central plates.

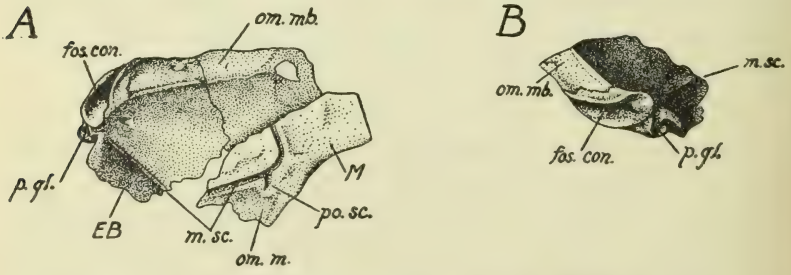
No recognizable Rostral (R) element has been observed.

Portions of both Externo-basal (EB) plates are preserved. The left one is contained in the shale block, lacking a fragment from its inferior margin. The outline of the missing fragment, however, is impressed on the shale. The less complete right Externo-basal is free. These elements are roughly triangular in shape, a rounded posterior edge forming the base of the triangle. The mesial or dorsal margin is almost straight and from immediately above the

condylar region forward, is widely overlapped by the lateral edge of the Median Basal. A prominent ridge limits laterally this depressed area of articulation. At the junction between dorsal and posterior borders the edge is thickened. This thickening is occupied by a broad and shallow condylar fossa. A horizontal line projected across the fossa meets the external contour line of the element in an angle of thirty degrees. The ventral lip of the fossa is more produced than the dorsal one. A small protuberance, the glenoid process, is developed on the lateral edge of the ventral lip. A distinct cleft remains, accommodating the sub-glenoid process of the Antero-dorso-lateral, between the dorso-laterally inclined face of the glenoid process and the external edge of bone which is confluent mesially with the dorsal lip of the fossa. The external surfaces of the plates are marked by the extensions of the marginal sensory canals and by a single pit situated above the condylar margin which presumably represent the externo-basal canals. Internally, the surfaces are without pronounced relief except for wide indented areas in the postero-dorsal portions of the plates, in all probability homologous with the postero-lateral impressions of *Dinichthys* (Heintz, 1932).

Only the postero-ventral angle of the Marginal (M) plate is present. The post-marginal sensory canal traverses the external surface of the fragment. On the inner surface and paralleling the posterior edge, there are several low ridges and shallow grooves on which possibly the post-marginal plate articulated.

The Post-orbital (PtO) plate, which is represented by the posterior portion of the right one crushed down on the right Externo-



TEXT FIG. 2. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). A. Left Externo-basal and Post-orbital plates in lateral aspect. B. Condylar fossa on left Externo-basal in posterior view. Approx. x 6/10.

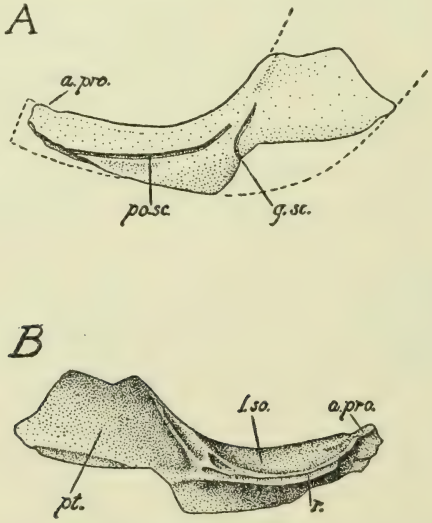
basal, is long, thin, and narrow. The lateral edge is gently concave and this concavity is only slightly interrupted by the projection of the indistinct post-orbital process. Seen from the inner surface, a weakly developed longitudinal ridge extends back a short way from the region of the post-orbital process. This ridge forms the mesial limits of the sub-orbital notch into which the antero-dorsal angle of the Sub-orbital plate abuts. The irregular posterior margin of the Post-orbital shows a depressed area for the overlap by the Marginal. The mesial edge of the plate is convex. From the contour of this edge and of the lateral one we can assume that the plate is more narrow in its anterior portion than behind. Externally, the marginal sensory canal extends forward from the postero-mesial corner of the plate and passes in a right angle curve inward onto the Central. A low ridge partially obstructs the complete junction between this canal and the short marginal portion of the sub-post-orbital canal.

The Pre-orbital (PrO) plates are crescentic elements fully as large as the Centrals. The entire left plate is exposed in dorsal aspect on the shale block. It tapers to a postero-lateral, finger-like extremity. The marginal contour of the plate, laterally, is concave, forming the dorsal and anterior borders of the orbits. The pre-orbital process is strongly developed. The extent of the free antero-inferior margin can not be accurately determined, but a concave portion of this edge, mesial to the pre-orbital process, perhaps indicates this dimension. The mesial margin is convex and is very irregular in outline. A distinct pre-orbital sensory canal traverses the length of the bone, paralleling the orbital border.

Bones of the Cheek and Visceral Skeleton. — The Sub-orbital (SO) plate is of the usual Arthrodiran type with a narrow infra-orbital handle and an expanded post-orbital portion. Only the left one was recovered with the specimen and it lacks fragments from the dorsal and inferior margins. A portion of the posterior margin, however, is entire, and from this it may be observed that the anterior handle is as long or longer than the posterior expanded portion of the plate. On the inner side of the handle the bone becomes gradually thickened from the thin dorsal edge ventrally, forming a longitudinal ridge, which continues the post-orbital border forward in a perfect arc. The dorso-mesially inclined surface between this ridge and the thin dorsal margin is concave in both transverse and frontal sections,

and serves as a lateral sub-orbital shelf. A comparatively broad shallow groove extends along the crest of the thickened ridge. That portion of the laterally deepened face of the handle ventral to the ridge is thin, and thus, appears sharply set off from the thickened portion in mesial view. Posteriorly, the inner ridge indistinctly bifurcates and becomes generally spread out into the expanded post-orbital portion of the Sub-orbital. One axis of the indistinct bifurcation follows the orbital margin and the other extends back to the posterior limits of the plate. Parts of both the sub-post-orbital and marginal sensory canals are exhibited on the lateral surface of the bone. These canals are not joined and neither approaches very closely the dorsal margin of the plate.

The Sclerotic (Sc) plates are represented by one well preserved element, a fragment and impression of another, and a fragment of a third. The plates are long, narrow, and quite thin. On either end of a plate, the slightly concave margin is produced into short pointed processes. The visceral surface of the one complete element exhibits striae which converge from the convex margin toward a center situated near the middle of the concave margin.



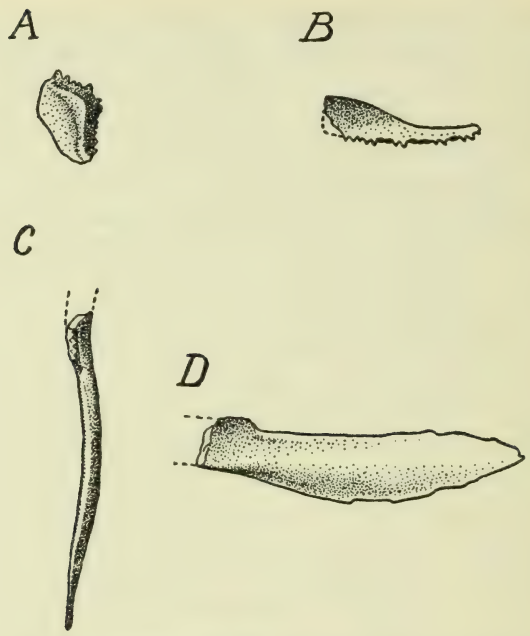
Text Fig. 3. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). A. Left Sub-orbital plate in lateral view. B. The same plate in mesial view. Approx. x 6/10.

A fragment of bone, exhibiting a thickening on its inner surface similar to the thickening on the internal surface of a Dinichthyid Post-sub-orbital plate, was discovered with the specimen. Because of this structure, the fragment has been identified as the Post-sub-orbital of the present form. The bone is indicated to be of roughly triangular shape. Externally, it possesses a crescentic posterior exposed portion and an anteriorly directed flange which the postero-dorsal edge of the Sub-orbital plate overlapped. The thickening in the center of the inner surface is composed of an elevated ridge encircling a central depression.

Both right and left Antero-supra-gnathal (ASG) plates are preserved. In dorsal aspect these elements present a triangular appearance. The main body of each has the form of a thin horizontal plate. A heavy dorsally projecting ridge is developed along the anterior and lateral margins of this plate. The ridge is most produced near the angle of junction between the anterior and lateral faces and diminishes in height both mesially and posteriorly. A single row of twelve tooth-like tubercles project down from the inferior margin of this ridge. The "teeth" are very uneven in size and also in spacing. The ventral surfaces of these gnathal elements could not be prepared but from the thinness of the horizontal plate we may, perhaps, safely assume that it is quite flat.

The Postero-supra-gnathal (PSG) elements are long and thin. The right one, alone preserved in its entirety and with the inner side exposed, is most deep anteriorly and becomes reduced to a very low posterior termination. The dorsal margin of this plate is concave and seems to coincide with the contour of the inferior border of the sub-orbital ridge. The oral border of the Postero-supra-gnathal is almost straight and a single series of some eighteen tubercles are developed here.

Our knowledge of the Infero-gnathal (IG) is limited to the blade portion and the most posterior of the functional portion of the left element. The blade is only moderately expanded and is quite thick. Its posterior extremity is pointed. The tubercles on the oral margin are large and appear to be in a double irregular series. They project above the level of the dorsal edge of the blade portion, even with the perpendicular lateral surface of the bone. The dorsal margin of the element is thicker in this region than the base of the tubercles,



TEXT FIG. 4. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). A. The right Antero-supra-gnathal from above and slightly anteriorly. B. Inner surface of the right Postero-supra-gnathal. C. & D. Dorsal and lateral views respectively of the left Infero-gnathal. Approx. x 6/10.

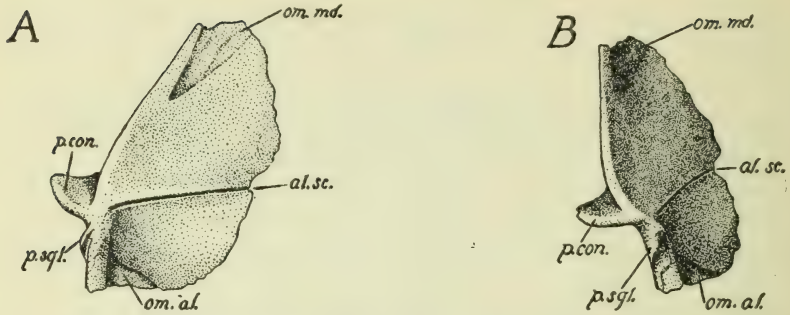
and consequently an interno-dorsal longitudinal shelf results. Assuming that the combined lengths of the two supra-gnathal elements equals approximately the length of the functional portion of the Infero-gnathal, we have restored the missing anterior portion of this latter plate. If correct, the blade and functional portions each occupy half the total length of the bone. It seems doubtful, because of the plate-like nature of the Antero-supra-gnathal, that any anterior cusp development existed.

Bones of the Body Carapace. — The Median Dorsal (MD) is longer than wide. Its anterior margin bears three processes; a short median one, and a pair of long lateral ones. The posterior margin is broadly rounded. Ventrally, a low median keel is developed only in the posterior half of the plate. This keel becomes gradually heavier from front to back and terminates in a dorsally grooved process

which projects beyond and below the rounded margin of the dorsal plate.

The left Antero-dorso-lateral (ADL) plate is preserved, lacking portions of its posterior and inferior margins. The element is peculiarly developed and exhibits the features which contribute to the remarkably long unarmored nuchal space referred to in the generic diagnosis. The bone is much deeper than long. The lateral surface may be divided into dorsal and ventral portions, above and below the horizontal level of the condyle. The antero-lateral sensory canal extends across the plate at approximately this level. The anterior margin of the ventral portion is much thickened. The face of this portion is inclined dorso-laterally at an angle of 25 degrees from the vertical when the condyle is horizontal. As usual, this face is overlapped in part by the Antero-lateral plate from below. Only a small portion of this overlapped portion is preserved on the present plate. However, from evidences on the inner surface of the Antero-lateral, the ventral overlapped margin of the Antero-dorso-lateral is extensive. Dorsal to the horizontal level of the condyle, the lateral surface of the plate is inclined at an angle of 35 degrees from the vertical. The anterior margin of the dorsal portion extends rather sharply backwardly, and dorso-mesially. A V-shaped depression, accommodating the overlapping antero-lateral process of the Median Dorsal occurs on the postero-dorsal expansion of the plate. The Median Dorsal overlap is not as extensive as in *Dinichthys*, and certain other of the Cleveland Shale Arthrodira. Comparatively, therefore, the free anterior margin of this plate dorsal to the condyle is long. The condyle is moderately developed. The weak sub-glenoid process projects from the anterior margin of the plate below the base of the condyle. Its articular face is inclined ventro-mesially. The inner surface of the entire bone is generally smooth.

The left Postero-dorso-lateral (PDL) element is embedded, with a fragment of the right one, in the shale, partially covered by the Externo-basal and Antero-lateral plates. The visible margins reveal a bone of approximately the same size as Antero-dorso-lateral; much deeper than long. The broad areas of the plate overlain by the Median Dorsal, Antero-dorso-lateral, and Postero-lateral are clearly defined. There is no evidence that the antero-lateral sensory canal is extended back on this bone.



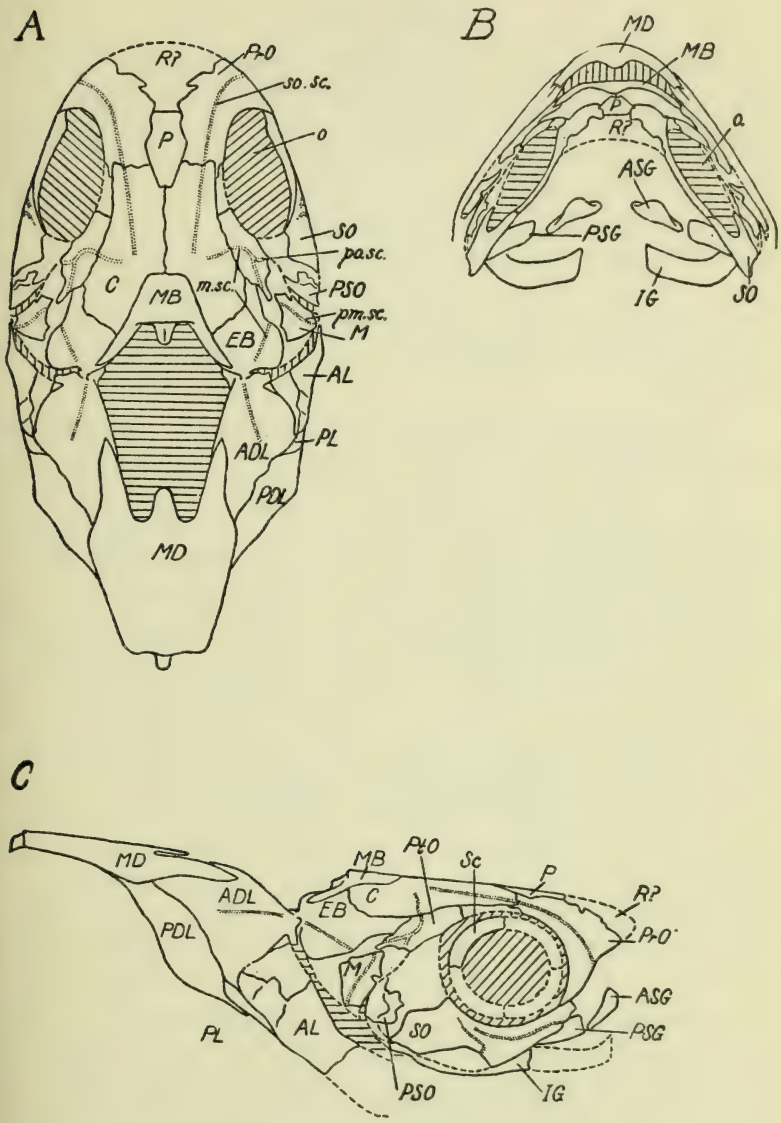
Text Fig. 5. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). A. Left Antero-dorso-lateral in lateral view. B. The same plate in anterior view. Approx. x 6/10.

Only the dorsal half of the left Antero-lateral (AL) plate is preserved. Fortunately, the outline of the posterior edge of the missing portion is impressed on the shale, and the full ventral extent of the bone can be observed. The bone, thus revealed, is remarkably deep, and comparatively short. The posterior margin appears to have been almost straight. The anterior margin of the preserved portion is thickened and this thickening is occupied by a groove. The inner surface of the plate exhibits a vertical ridge and paralleling grooves which indicates the area overlapping the ventral extension of the Antero-dorso-lateral.

The Postero-lateral (PL) is a small triangular plate. The right element is preserved and shows distinctly the margins overlapped by the Antero-dorso-lateral and the Antero-lateral plates.

No trace of the Spinal or Intero-lateral plates has been found.

Little can be said of the ventral body armor. Of the four remaining plates associated with the specimen, two are so fragmentary as to preclude discussion. The other two are thin, paired, cleaver-shaped elements, which we have tentatively identified as the Antero-ventro-lateral (AVL) plates. On the inner surface of each bone there are two pronounced depressions, interpreted as the areas overlain by the Antero-median-ventral and the Postero-median-ventral. A shaft-like process is extended backwardly. The dorsal surface of this portion is somewhat rugose and suggests a contact with the ventral surface of a Postero-ventro-lateral.



Text Fig. 6. *Gymnotrachelus hydei* (CMNH. Cat. Fos. Fishes No. 5724). Attempted reconstruction of the head shield and body carapace in (A) dorsal, (B) anterior, and (C) lateral views. Approx. x 3/10.

DISCUSSION

Several genera of Cleveland Shale Arthrodira have been previously described, which possess with *Gymnotrachelus* a small size. A relationship is suggested between the present form and *Trachosteus* by the similar structure of the Median Dorsal plates and by the presence in both of tuberculated gnathal elements. The development of these bones differs markedly in detail, however, between the two genera. Further, the bones of *Gymnotrachelus* are unornamented, the sclerotic plates are proportionately longer and narrower, and the structure of the Sub-orbital is dissimilar by comparison with the corresponding bones of *Trachosteus*, as figured by Dean (1909).

An affinity is hinted, again by the common possession in *Gymnotrachelus*, *Stenosteus*, and *Selenosteus* of tuberculated gnathal elements. In *Stenosteus* the length of the tuberculated functional portion of the Infero-gnathal is proportionately greater than in *Gymnotrachelus*. The form of the Antero-supra-gnathals differ widely between the two forms, as do also the general contours of the Antero-dorso-lateral, the Sub-orbital, and the Sclerotic plates. In *Selenosteus* the length of the functional portion of the Infero-gnathal is proportionately less than that of *Gymnotrachelus*. As in *Stenosteus*, the contours of the Antero-dorso-lateral, the Sub-orbital, and the Sclerotic plates, as well as those of the Median Dorsal, the Median Basal, and the Externo-basal plates of *Selenosteus* vary widely from the corresponding plates in *Gymnotrachelus*. The plate-like Antero-supra-gnathal of *Gymnotrachelus* is suggestive of the Mylostomid condition. In our present limited knowledge only two additional characters seem to further support this suggested relationship between *Mylostoma* and the present form; namely, the similar development of the Median Basal and Antero-dorso-lateral plates.

The above comparisons are by necessity broad and obvious. It must be remembered that the genera referred to may be grouped as the rarest of the Cleveland Shale Arthrodira and are in most cases inadequately known. It is, therefore, perhaps excusable that we do not make any definite statement concerning the affinities of *Gymnotrachelus* until our current study of the Cleveland Museum Collection is further advanced.

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EXPLANATION OF THE LETTERING USED IN THE TEXT FIGURES

AL. Antero-lateral
al. sc. Antero-lateral sensory canal
a. pro. Articular surface for the pre-orbital process
ASG. Antero-supra-gnathal
AVL. Doubtful Antero-ventro-lateral
EB_1. Left Externo-basal
fos. con. Condylar fossa
g. sc. Gnathal sensory canal
i. ac. sc. Impression of the middle head line
i. AL_2. Impression of the right Antero-lateral
i. C_{1-2}. Impressions of the left and right Centrals respectively
IG. Infero-gnathal

i. pr. sc. Impression of the pre-orbital sensory canal
i. pt. sc. Impression of the sub-post-orbital sensory canal
l. so. Lateral sub-orbital shelf
M. Marginal
MB. Median Basal
MD. Median Dorsal
m. sc. Marginal sensory canal
o. Orbit
om. al. Antero-lateral overlap area on the Antero-dorso-lateral
om. av. Overlap margin for the Antero-median-ventral
om. m. Marginal overlap area on the Post-orbital
om. mb. Median Basal overlap area on the Externo-basal
om. md. Median Dorsal overlap area on the Antero-dorso-lateral
om. pdl. Overlap margin of the Postero-dorso-lateral
om. pv. Overlap margin for the Postero-median-ventral
P. Pineal
p. al. Antero-lateral process of the Median Dorsal
p. am. Antero-median process of the Median Dorsal
p. con. Condylar process
PDL_{1-2}. Left and right Postero-dorso-lateral, respectively
p. gl. Glenoid process
PL. Postero-lateral
pm. sc. Post-marginal sensory canal
po. sc. Sub-post-orbital sensory canal
pp. Pituitary pit
PrO_{1-2}. Left and right Pre-orbitals, respectively
PSG. Postero-supra-gnathal
p. sgl. Sub-glenoid process
PSO. Post-sub-orbital
p. sp. Postero-median spine of the Median Basal
pt. Posterior expanded portion of the Sub-orbital
p. vk. Keel of the Median Dorsal
R?. Restored Rostral
r. Internal ridge on the Sub-orbital
Sc_{1-2-3}. Sclerotics
SO. Sub-orbital
so. sc. Pre-orbital sensory canal
V?. Doubtful ventral plates

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ON ONE OF THE LEAST KNOWN OF THE CLEVELAND SHALE ARTHRODIRA

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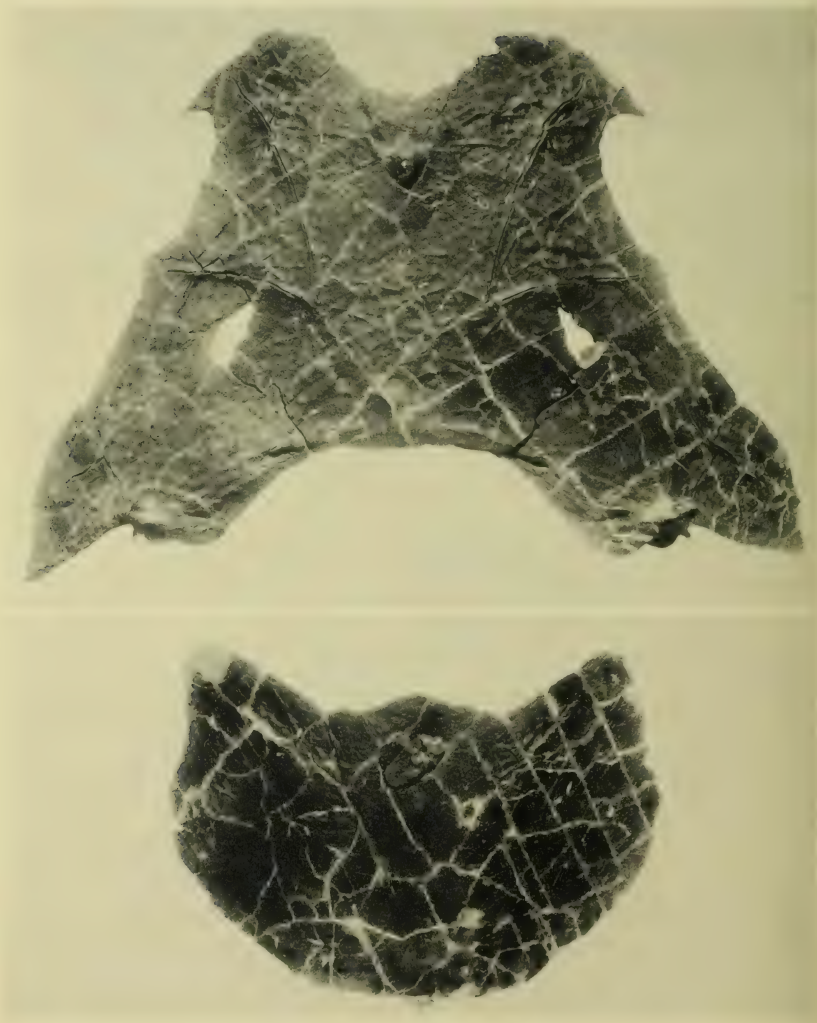

PLATE IV

Gorgonichthys clarki Claypole (CMNH. Cat. Fos. Fishes No. 5117). Photographs of the cranial shield and Median Dorsal plate in dorsal view. Approx. x 1/9.

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INTRODUCTION

Among the specimens of Upper Devonian fishes collected by The Cleveland Museum of Natural History during the summer of 1939 are the right and left Infero-gnathal and right Antero-supra-gnathal plates of the Arthrodiran now recognized as *Dinichthys clarki* (Claypole, 1892). Associated with these gnathal elements, as found, were an Antero-lateral plate and a Postero-dorso-lateral plate. By a comparison of these latter bones with the corresponding elements from other specimens, it has been possible to relate the "*D*". *clarki* type of mouth parts with a fairly complete and heretofore undescribed cranial shield and body carapace. Thus revealed, the form possesses a number of very remarkable features, and a preliminary description of its structure is presented here. It has been necessary to leave unanswered several important questions but the authors propose returning to these at some future date.

The study is based upon the following complete list of specimens from the Collections of this Museum which we have been able immediately to identify as "*Dinichthys*" *clarki*.

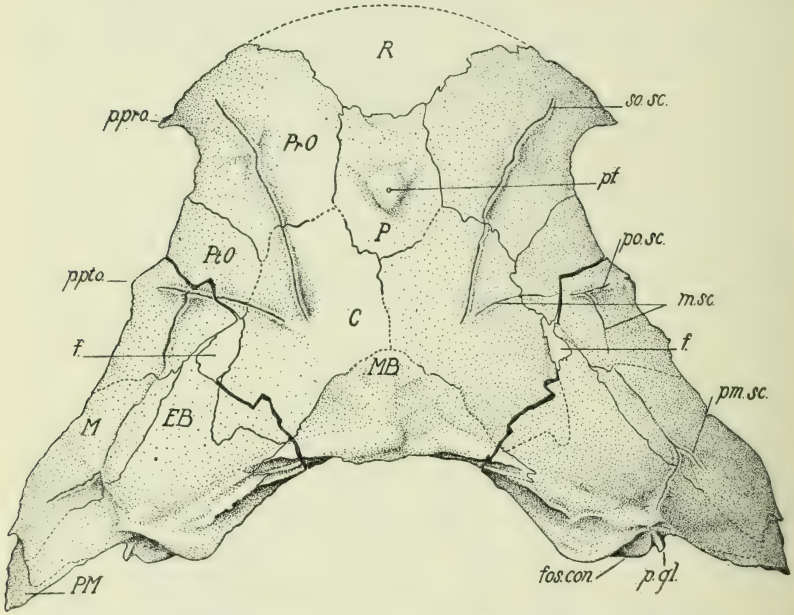
No. 5001. Associated right and left Infero-gnathal plates. Lower concretionary zone of the Cleveland Shale on Big Creek, (Berea Quadrangle), Cuyahoga County, Ohio. Collected: Summer, 1918 by P. A. B.

No. 5010. Left Antero-supra-gnathal plate. Cleveland Shale on Black River, Sheffield Township (Oberlin Quadrangle), Lorain County, Ohio. Collected: Summer, 1916 by P. A. B.

No. 5027. Associated right and left Infero-gnathal, Cleveland Shale on Black River, Sheffield Township (Oberlin Quadrangle), Lorain County, Ohio. Collected: 1923 by P. A. B.

No. 5117. Head shield and body carapace; lacking only the Sub-orbital plates, the mouth parts, and a few other plates. Cleve-

This complex of dermal roofing bones was prepared and reassembled in three large parts: a central portion, and two posterolateral wings (cf. Text Fig. 1). This method was necessary because the bones, which are extremely thin, were not considered sufficiently



Text Fig. 1. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 5117). Dorsal view of the cranial shield somewhat restored. Approx. x 1/9.

strong to support a complete restoration. It is believed that the thinness of the bone has resulted from external pressures exerted during preservation on an originally thick spongy bone tissue. In cross-sections such elements as the Centrals, normally plate-like, are seen to be composed of the broken fragments of the bone lamellae crushed together in a dense, compact sheet. Few, if any, cell spaces are preserved. A similar condition obtains even in those portions of the Median Basal and Externo-basal plates, which generally among Arthrodira are excessively thickened. Sections through the transverse ridge of the Median Basal and the condylar fossa portion of the Externo-basal show a complete collapse of the bone structure in the cores of these areas. The microscopic structure of the denser external layers of bone in these areas has not been destroyed but these layers have been fractured in irregular blocks and slivers. The in-

ward compression of these latter perhaps accounts for the breakdown of the internal structure. The large size of the undistorted cell spaces observable is a further fact which seems to support our conviction in the original thick and loosely knit character of this bone.

In outline, the shield is roughly a wide based trapezoid. Anteriorly, as restored, it is broadly rounded while its basal border is shallowly concave. Laterally, the margins extend generally outward to the tips of the Post-marginal plates, across which the greatest breadth of the shield occurs. The anterior third of the lateral margin is occupied by the concave indentation of the enormous orbit, and the posterior two-thirds of this border has a slightly convex outline.

In size, the cranial shield exceeds that attained by the average *Dinichthys intermedius* and approaches that of the larger species, *D. terrilli*. The measurements, taken in order to characterize here certain length-breadth ratios, were made on the dorsal surface of the shield and over the existing curvatures so that any flattening suffered during preservation might be discounted. The median length is slightly less than the breadth between the extremities of the prominent pre-orbital processes, and is contained approximately twice in the greatest width, across the basis of the shield.

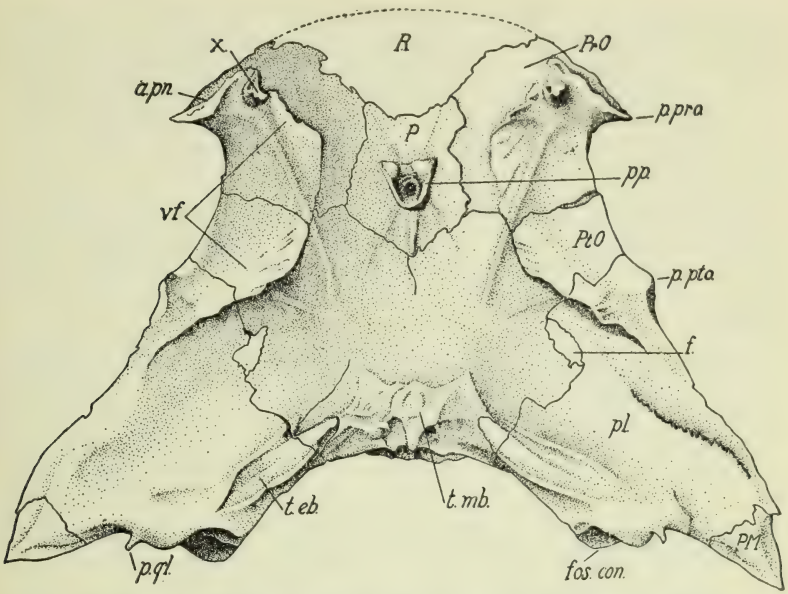
The external surface of the bone is smooth and unornamented. In dorsal aspect, the shield is gently arched both from front to back and from side to side. Its depth from the highest point on the Median Basal to a horizontal line between the Post-marginal tips, is approximately 20 cm. The present writers assume that this depth would not be appreciably increased were it possible to restore the shield to its original contours and therefore consider the form to possess a short, exceptionally broad and shallow head. This contention is based primarily on the apparently normal position and comparatively undistorted condition of the condylar fossae. Lines projected across the axes of the fossae are extended dorso-laterally and ventro-mesially. An elevation of only 8mm. of the fossae mesially by a further arching upward of the Median Basal or an equivalent depression of the fossae laterally by a dropping of the marginal wings is necessary to bring these structures in a straight horizontal line with each other; the position which alone allows unobstructed movement of the head shield on the body carapace. Traces of deformation in these regions are exhibited. These evidences are discounted, however, because they are confined to the posteriorly produced dorsal lips of the fossae and to the thin roofs of the anteriorly adjacent ventral areas termed by Heintz (1932) the postero-lateral impressions.

Of remarkable occurrence are a pair of openings which pierce the shield at or near the juncture of the Central, Post-orbital, and Externo-basal plates on either side. These right and left fenestrae are approximately equally developed. That on the left is slightly larger, due to the unavoidable breaking during excavation and preparation of the extremely thin and frayed out margins of bone surrounding it. Superficially, the fenestrae appear to be normal in the shield of this specimen of "*Dinichthys*" *clarki*. However, it must be pointed out that they could conceivably have been formed by either one of two methods as a result of the flattening of the shield during preservation. One of these methods is a transverse separation between the lateral margin of the Central and the mesial edge of the Post-orbital plates. The other method is a slipping on the Median Basal-Externo-basal, Central-Post-orbital, and Post-orbital-Pre-orbital sutures so that the complex of Externo-basal, Post-marginal, Marginal, and Post-orbital plates was pulled postero-laterally as a unit. No recognized evidence is exhibited in support of the former method. Neither is there any evidence in support of the latter, save for a slight slipping in an antero-posterior direction on the transverse Pre-orbital-Post-orbital suture. Perhaps it is best that judgment on these fenestrae, either as a normal specialization or as having been formed subsequent to burial, be postponed until additional specimens of this form may be obtained.

The sensory canals form deep and exceptionally narrow grooves, paralleled on either side by ridges. With the exception of an Externo-basal canal, all are developed; arranged in typical Arthrodiran pattern.

In ventral view, the cranial shield is concave both antero-posteriorly and transversely. Its posterior border between the condylar fossae is seen to be thickened in a transverse ridge which corresponds to the "posterior consolidated arch" of Heintz (1932). The portions of the ridge on the Externo-basals is short and very low. Mesially, on the median Basal it is lengthened and is more elevated. The posterior margin of the thickening is deeply grooved transversely. The median spine is developed as an indistinct vertical prominence which divides the posterior groove into equal lateral portions. A number of depressions and processes are displayed on the ventral surface of the transverse ridge, mesially. The whole area has been so badly distorted, however, that it is difficult to determine whether these structures are even comparable with those described in *Dinichthys intermedius* by Heintz.

The well developed condylar fossae occupy the lateral extremities of the transverse ridge. These are semi-circular in sagittal section and the width of each is approximately one tenth of the basis of the



Text Fig. 2. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 5117). Ventral view of the cranial shield somewhat restored. Approx. x 1/9.

shield. The dorsal and ventral lips are equally developed but in their areas of greatest prominence are not situated one above the other. The dorsal lip which is continuous with the dorsal margin of the Externo- basal has its most posteriorly produced portion over the mesial half of the fossa. Laterally, this lip diminishes and merges below with the posterior margin of the plate. The ventral lip arises on the mesial face of the Externo-basal and has its greatest prominence beneath the lateral half of the fossa. An exceptionally small glenoid process projects postero-laterally from the lateral margin of the ventral lip.

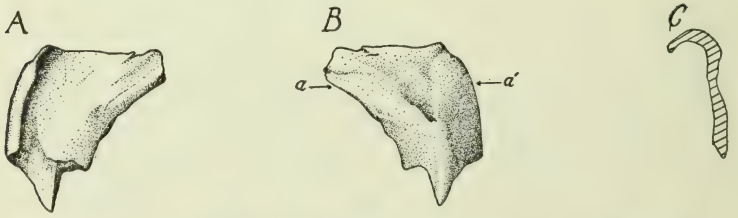
A ventro-mesially produced flange is developed on the Pre-and Post-orbital plates which corresponds to the "lateral consolidated part" of Heintz. This flange is highest in the transverse planes of the pre- and post-orbital processes and forms a cup-like structure which serves as the roof of the orbit. No neurocranial processes are present. Behind the post-orbital process the flange merges with the general ventral surface of the shield so that neither the expanded ventral border of the marginal series of plates nor the mesially adjacent postero-lateral impressions are clearly defined. Ante-

riorly, the high flange parallels but is set back from the ventral border of the Pre-orbital. The groove thus formed is associated with the articulation of the Sub-orbital and Post-nasal plates to the Pre-orbitals. Mesial to this area a heavy descending process is developed which has the same shape as a miniature neurocranial process of *Dinichthys intermedius*. The function of this latter structure has not been determined.

A pronounced elevation near the center of the Pineal plate encloses the pituitary pit. The elevation is posteriorly narrow and high. Anteriorly its margins gradually diverge and become very low. A foramen completely penetrates the shield roof from within the pit.

The sutures between the component plates of the shield have been largely obliterated. Only isolated portions are at all discernible (Text-Fig. 1 & 2) and so little can be added to the above description by a consideration of the individual elements. In the drawing of the shield in dorsal view (Text-Fig. 1) the liberty has been taken of connecting the observable suture fragments with dotted lines. This has indicated that the usual number of bones are present and are arranged in a typical Arthrodiran pattern.

Bones of the Cheek and Visceral Skeleton:—The material at hand contains none of the bones of the cheek and of the visceral skeleton only the Antero-Supra-gnathal, Infero-gnathal, and Post-infero-gnathal plates are represented.



Text Fig. 3. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 7129). A & B. Mesial and lateral views, respectively, of the right Antero-supra-gnathal plate. C. Lengthwise section in the plane a-a' indicated by arrows on Fig. B. Approx. x 1/9.

The Antero-supra-gnathal is a large element of distinctive shape. In frontal section it has the form of an inverted "L"; the long shank being the lateral main body of the bone and the short arm being the mesially directed anterior portion. An amazing uniformity of thickness is maintained throughout the plate. The antero-lateral angle between the two arms of the element is rounded. The ventral

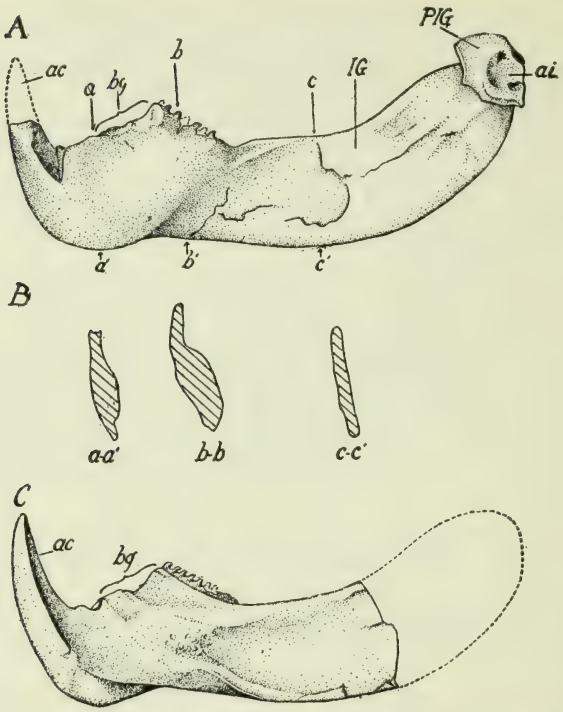
margin at this angle is produced in a low pointed cusp which is opposed to a shearing groove between the anterior "tooth" and lateral flange of the Infero-gnathal plate. Above and behind the cusp is a short, blunt shelf. This also touches the Infero-gnathal but, being directly opposed to the wide dorsal margin of the latter element, crushes rather than shears. The lateral portion of the plate is produced postero-dorsally in a deep process which, unlike the inwardly curving and thickened posterior process of the typical Dinichthyid Antero-supra-gnathal, is practically vertical and is directed straight back.

The Infero-gnathal of "*D*" *clarki* is represented in the collection by three pairs of complete and fragmentary plates. Of these, Specimen No. 7129 is described here as the most complete and least worn. From a comparison of the size of the Antero-lateral and Postero-dorso-lateral plates, found associated with this pair of lower "jaws", with the corresponding bones of Sp. No. 5117, it may be assumed that the latter specimen possessed somewhat larger mouth parts.

The left Infero-gnathal, (Text-Fig. 4A) measures approximately 59 cm. in total length. As usual, the element is composed of two parts; commonly termed in Arthrodiran literature the "blade" and "functional" portions. The former occupies slightly more than the posterior half of the entire plate. In lateral view it is seen to be of uniform depth and to be tilted sharply upward to the rounded extremity. This portion is thin compared to the anterior "functional" part but is in reality very heavily constructed.

The posterior "blade" is bent slightly toward the median while the anterior portion is convex in lateral view. In frontal section, therefore, the Infero-gnathal forms a sigmoid curve. Mesially the transition from "blade" to "functional" part is not apparent. Laterally, however, the greater thickness anteriorly is displayed as a distinct step which extends from the ventral margin postero-dorsally across the depth of the element.

Anteriorly a truly formidable cusp is developed which measures 22.5 cm. in height. In section this "tooth" is roughly triangular. Posteriorly on the dorsal margin of the "functional" portion is a lateral flange. This arises sharply from the dorsal margin of the "blade" to about half the height of the anterior cusp. From this point the flange diminishes forward to the base of the "tooth" from which it is separated by a deep lateral V-shaped groove, worn by the cusp of the Antero-supra-gnathal. The forward slope of the flange is the extent of the lower "jaw" opposed to the Postero-supra-gnathal plate. The length of this margin is exception-

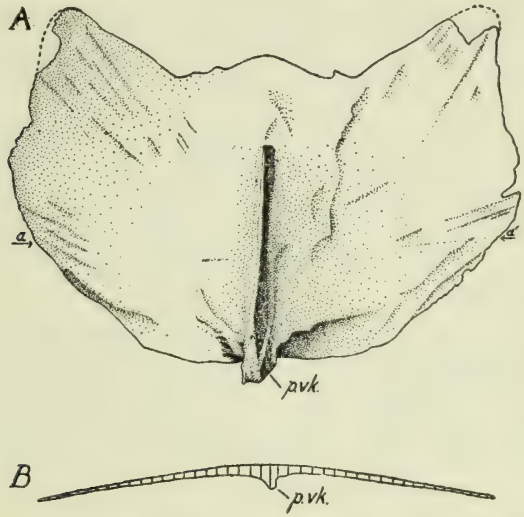


Text Fig. 4. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 7129). A & C. Lateral view of the left and mesial view of the right Infero-gnathal plates, respectively. B. Three transverse sections through the left Infero-gnathal corresponding to the labeled planes indicated by arrows on Fig. A. Approx. x 1/9.

ally short. The flange in this area is comparatively thick and instead of forming a sharp cutting edge so typical of the better known species of *Dinichthys*, it is blunt and longitudinally grooved as a crushing surface. The posterior slope of the flange bears a variable number (6, 7 or 8) of heavy denticles, whose tips are characteristically bent inward.

Firmly attached to and overlapping laterally the posterior extremity of the left Infero-gnathal (Text-Fig. 4 A) is a fragment of the Postero-infero-gnathal plate. The portion preserved is badly crushed but clearly shows the original cancellous nature of the element. On its lateral surface a central depression and encircling ridges are discernible which is the structure movably articulating with a corresponding facet on the Post-sub-orbital plate.

Bones of the Body Armor: — The Median Dorsal plate is as usual the largest single element of the body carapace. Its general proportions, on the other hand, are rather uncommon in that the median length is only about one half the maximum width. In dorsal aspect, the plate is slightly arched from side to side, and the surface is smooth.



Text Fig. 5. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 5117). A. Ventral view of the Median Dorsal plate. B. Section in the plane a-a' indicated by arrows on Fig. A. Approx. x 1/9.

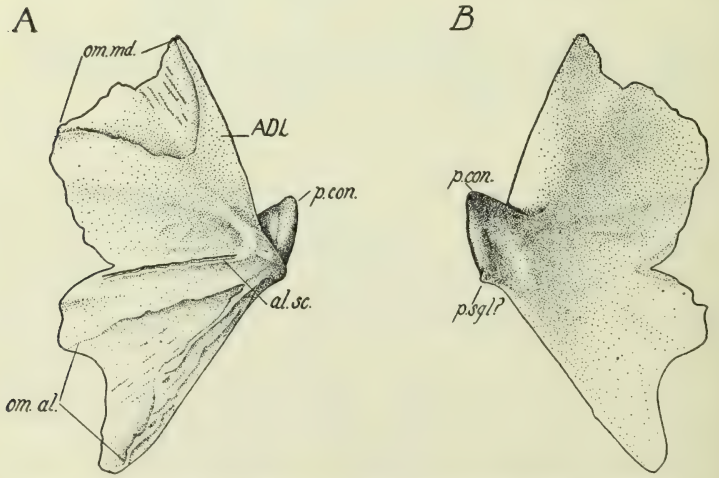
The anterior margin is marked by three bluntly rounded processes; a short median one, and a longer lateral one at either side. From the extremities of the lateral processes the margins extend backward and laterally to the plane of greatest width located across the center of the plate. From this plane of maximum breadth, the lateral margins curve gently backward and mesially to become confluent with the broadly convex posterior border. Along the median line ventrally, a low but comparatively thick keel is developed. It arises about a quarter of the entire length behind the anterior margin and increases very gradually both in depth and stoutness posteriorly. The extremity is dorsally grooved and projects but little beyond the posterior margin of the dorsal plate.

The Antero-dorso-lateral is large and is sub-triangular in shape: the condyle at the middle of the anterior margin forming the apex,

and the irregular posterior margin the base. In normal position the anterior margin above the condyle would slope acutely upward and backward while that below the condyle would be extended almost directly ventrally. This indicates a rather long unarmored dorsal nuchal space which, considering the breadth of the Median Dorsal, was very wide as well.

In lateral view, the plate is slightly convex dorso-ventrally and this surface exhibits two well defined impressed areas. A comparatively small one on the postero-dorsal angle shows the shallow overlap on the Antero-dorso-lateral by the antero-lateral process of the Median Dorsal. The other impression is ventral and is that area covered by the Antero-lateral plate. This is carried upward to just below the condyle and is characterized by several heavily developed ridges and grooves. The deep narrow groove of the Antero-lateral sensory canal extends from the region of the condyle downward and backward and terminates before reaching the posterior margin.

The mesial surface of the Antero-dorso-lateral is flat and smooth. The only prominence is a gradual thickening to form the base of the condyle from the center of the plate forward. The condyle is broad and strongly developed. It is confluent laterally with the anterior margin of the bone. Mesially, behind its straight anterior



Text Fig. 6. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 5117). A & B. Lateral and mesial views, respectively, of the right Antero-dorso-lateral plate. Approx. x 1/9.

margin, it gradually merges with the inner face of the plate. A small protuberance is situated ventro-laterally on the condyle which may be interpreted as the sub-glenoid process.

The Postero-dorso-lateral is an element of much greater height than length and is generally crescentic in outline. The posterior margin of the bone is the concave side of the crescent, and the anteriorly expanded border the convex side. Mesially, the surface is without relief. Externally, distinctly impressed areas indicate the extent of overlap by the dorsal Median Dorsal, anterior Antero-dorso-lateral, and the ventral Postero-lateral.

The Antero-lateral plate is relatively small and possesses a highly specialized structure. The plate is roughly triangular in outline with an expanded postero-dorsal portion, and a slender antero-ventrally produced process. Its anterior margin is gently concave. In both of the two Antero-lateral plates contained in the collections, the posterior margins appear thin and frayed out. It is difficult to determine whether they are entire and, if not, what the maximum extent of the element might have been. Ventrally, the margin of the anterior process is carried upward and backward in a gentle curve, and as a ridge merges with the posterior expanded portion of the bone on its inner face. The ventral margin of the posterior expanded part extends forward external to the anterior process. A lateral flange is thus formed along the ventral border of the bone. This condition is similar to that found in *Stenognathus* and *Titanichthys* (Heintz, 1931a), and is in marked contrast to the structure of a typical Dinichthyid Antero-lateral. The inner surface of the expanded portion of the plate is marked by generally vertical ridges and grooves on which a firm overlap of the Antero-dorso-lateral plate is effected. Externally a deep impression parallels the anterior margin high on the dorsal expansion. A somewhat similar depression is observable on the Antero-lateral of *Stenognathus*, located immediately above the angle in the concave anterior margin.

No recognizable traces of either a Postero-lateral plate or an Intero-lateral plate has been found among the "*D*". *clarki* material.

Of the bones of the body plastron, only a right Antero-ventro-lateral, and a right Postero-ventro-lateral are contained in the present material. Both of the plates, although neither is complete, are very large. The former element is indicated to be as broad as long. It is of uniform thickness and is unmarked by any prominent ridges or process. The Postero-ventro-lateral is indicated to be a long slender plate; its maximum width being only one third the length of the preserved portion. Ventrally, at the center of ossification is an area closely set with small rounded tubercles.

TEXT FIG. 7. *Gorgonichthys clarki* Claypole (CMNH. Cat. Fos. Fishes No. 5117). Disassociated right Postero-ventro-lateral, right Antero-ventro-lateral, right Antero-lateral, and left Postero-dorso-lateral: all in mesial view. Approx. x 1/9.

COMPARISON WITH *DINICHTHYS*

Taken alone, but omitting the crushing condition of its oral margin, the Infero-gnathal of "*D*" *clarki* is very similar in general outline with that of a typical Dinichthyid. However, the cranial shield and other bones described above present a number of features which diverge so widely from the distinct characters of the genus that a comparison is necessitated.

A number of the more important differences may be listed as follows:

1. The cranial shield is short, broad, and very low.

2. The orbits are enormous.

3. The Central is apparently excluded from lateral contact with the Marginal.

4. The glenoid process is very small.

5. The various ventral thickenings are less prominently developed and the characteristic neurocranial processes are absent.

6. The structure of the Antero-supra-gnathal indicates morphological differences of great importance.

7. The oral margin of the Infero-gnathal opposed to the Postero-supra-gnathal is short, thick, and longitudinally grooved for crushing.

8. The Median Dorsal is approximately twice as broad as long.

9. The Antero-dorso-lateral is only shallowly overlapped on its postero-dorsal angle by the Median Dorsal.

10. The structure of the Antero-lateral is very specialized.

Several of the differences enumerated above are of much more taxonomic importance than the others. As will be described in subsequent papers the Antero-supra-gnathals are known to be, by a complex arrangement, articulated to a number of undescribed elements which are associated ventrally with the ethmoidal portion of the neurocranium. The posteriorly directed "handle" of the "*D*" *clarki* Antero-supra-gnathal indicates a totally different arrangement of these parts compared with the inwardly extended and thickened postero-dorsal processes of the corresponding Dinichthyid element.

The other feature of greatest contrast is evidenced in the structure of the Antero-lateral. The antero-ventral process of this element in *Dinichthys* is forked into forwardly tapering mesial and lateral flanges. The Intero-lateral plate overlaps the outer face of the mesial flange. As brought out by Heintz (1931 a) in a study of this element from *Stenognathus* and *Titanichthys*, the anterior process present in "*D*" *clarki* Antero-lateral is to be homologized with the mesial flange developed in typical *Dinichthys*. The lateral one is represented in this form only by the outwardly curving ventral margin of the plate.

RELATIONSHIPS

From the foregoing brief account, these writers are convinced that the *clarki* species must be removed from the genus *Dinichthys*. We here propose that Claypole's original name of *Gorgonichthys* be re-established for the reception of this form, which may be diagnosed as follows:

A very large Arthrodire with broad flattened head shield and body carapace. Bones, as preserved, very thin; smooth and unornamented. Orbits enormous; limited in front by a strongly developed pre-orbital process; post-orbital less distinctly developed. Dorsal unarmored nuchal space indicated to be comparatively long.

Limits of the individual bones and their sutural connections not fully known but indicated to be of the usual number and arrangement. Centrals excluded from contact with Marginals. Normal fenestration of the shield roof at the junction of the Central, Post-orbital, and Externo-basal plates probable. Transverse and lateral thickenings on the ventral surface of the shield low and weakly produced. Condylar fossae broad and heavy; glenoid process small. Antero-supra-gnathal with form of inverted "L" in section; postero-dorsal extremity straight and strongly produced. Infero-gnathal long and very heavy; "blade" portion sharply uptilted; extremely high anterior cusp developed; portion of oral border opposed to the Postero-supra-gnathal short, thick, and longitudinally grooved for crushing.

Median Dorsal approximately twice as wide as long; median ventral keel low and not extending to the anterior margin of the element; posterior, dorsally grooved extremity not produced much beyond the posterior margin of the dorsal plate. Antero-dorso-lateral roughly triangular; deeper than long; anterior margin dorsal to condyle extending markedly upward and backward; condyle broad and heavily developed; sub-glenoid process present but exceptionally small. Postero-dorso-lateral crescentic; laterally showing the usual impressed areas on its anterior margin for the overlap of adjacent plates. Antero-lateral roughly triangular with postero-dorsal expanded portion and forwardly tapering, unforked antero-ventral process.

Sensory canals developed as deep narrow grooves. The externo-basal canal is not present. All others arranged in normal pattern.

Concerning the affinities of *Gorgonichthys clarki*, it may be briefly stated at this time, that the form is very closely related to *Stenognathus*. With but few exceptions the points of difference listed in the comparison between *Dinichthys* and the present form are structural features which between *Stenognathus* and *Gorgonichthys* are almost identically developed.

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EXPLANATION OF THE LETTERING USED IN THE TEXT-FIGURES

ac. Anterior cusp
ADL. Antero-dorso-lateral
ai. Supposed articular impression on the Postero-infero-gnathal
AL. Antero-lateral
al. sc. Antero-lateral sensory canal
a. pn. Articular surface on the Pre-orbital for the Post-nasal
ASG. Antero-supra-gnathal
AVL. Antero-ventro-lateral
bg. Margin opposed to the Postero-supra-gnathal
C. Central
EB. Externo-basal
f. Fenestra
fos. con. Condylar fossa
IG. Infero-gnathal
M. Marginal
MB. Median Basal
MD. Median Dorsal
m. sc. Marginal sensory canal
om. al. Antero-lateral overlap area on the Antero-dorsal-lateral

om. md. Median Dorsal overlap area on the Antero-dorsal lateral
P. Pineal
p. con. Condylar process
PDL. Postero-dorso-lateral
pf. Pineal foramen
p. gl. Glenoid process
PIG. Postero-infero-gnathal
PL. Postero-lateral
pl. Postero-lateral impression
PM. Post-marginal
pm. sc. Post-marginal sensory canal
po. sc. Post-sub-orbital sensory canal
pp. Pituitary pit
p. pro. Pre-orbital process
p. pto. Post-orbital process
PrO. Pre-orbital
p. sgl. Sub-glenoid process
PtO. Post-orbital
p.vk. Ventral keel of the Median Dorsal
PVL. Postero-ventro-lateral
R. Rostral
so. sc. Pre-orbital sensory canal
t. eb. Externo-basal thickening
t.mb. Median Basal thickening
vf. Ventral flange of the Pre- and Post-orbital plates
x. Heavy ventral projecting process of the Pre-orbital

PLATE V

Gorgonichthys clarki Claypole. A. Left Antero-supra-gnathal in lateral view (CMNH. Cat. Fos. Fishes No. 5010). B. Left Postero-dorso-lateral in lateral view (CMNH. Cat. Fos. Fishes No. 7129). C. Left Infero-gnathal in lateral view (CMNH. Cat. Fos. Fishes No. 5001). D & E. Mesial view of the left and lateral view, respectively, of the right Antero-

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THE INFERO-GNATHAL PLATES OF *TITANICHTHYS*

BY
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The junior author of the present contribution has long maintained that the infero-gnathal plates of *Titanichthys* always have been oriented incorrectly, upside down and interchanged from side to side. During the recent routine identifications of the Arthrodiran specimens in the collections of the Cleveland Museum of Natural History, a number of morphological features were observed which it proves practicable to interpret in support of this contention. It is the purpose of this paper to describe these evidences, and to present a corresponding interpretation of the orientation of Titanichthyid lower mouth parts. While proof is admittedly lacking in the absence of complete specimens which exhibit all elements in their normal relationships to each other, the conclusions now offered nevertheless seem worthy of serious consideration.

The following descriptions pertain especially to the selected left infero-gnathal plates of *Titanichthys agassizii* Newberry and *Titanichthys clarkii* Newberry that are here figured. Despite wide variations in shape and general proportions, due apparently to differences in preservation, the details discussed are easily discernible on every available infero-gnathal plate from these 2 most common species of Cleveland Shale *Titanichthys*. In addition, the grosser structural features can be readily demonstrated on the corresponding elements of all other Titanichthyid types, of which there are at least 3 in the Cleveland Museum collections.

The present authors are indebted to the Marsh Fund of the National Academy of Sciences for a grant-in-aid toward the cost of the 1940 field expeditions, which made possible the collection of certain materials mentioned herein. Our thanks are due E. C. Stumm, Department of Geology, Oberlin College, who kindly permitted our examination of the type specimen of the so-called

History Survey

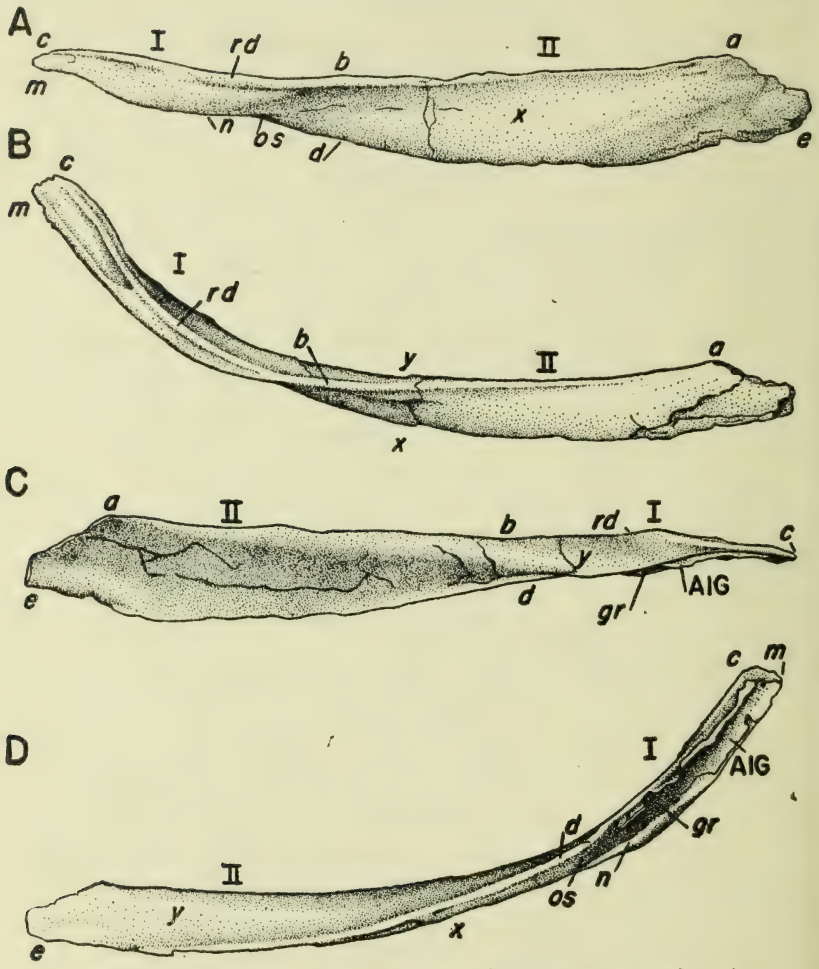

FIGURE 1. — *Titanichthys agassizii* Newberry (C.M.N.H. No. 6163). Left infero-gnathal plate in (A) lateral, (B) dorsal, (C) mesial, and (D) ventral views. Reproduction approximately x 1/7.

Explanation of Symbols. — AIG, antero-infero-gnathal plate; I, functional division; II, blade division; *a*, posterior point on the dorsal concave margin of blade; *b*, point on dorsal concave margin where the blade and functional portions are joined; *c*, mesial point on anterior extremity; *d*, point on ventral convex margin where the blade and functional portions are joined; *e*, posterior point on ventral convex margin of the blade; *gr*, longitudinal groove on ventral concave margin of the functional portion; *m*, lateral point on anterior extremity; *n*, posterior point on ventro-lateral margin of the functional portion; *os*, offset on lateral convex face; *rd*, dorso-mesial ridge on functional division; *x*, lateral convex face; and *y*, lingual concave face.

Titanichthys attenuatus Claypole[1]. Finally it is a real pleasure to repeat our expressions of gratitude to Mr. Guerdon S. Holden of Cleveland for his continued interest in these studies.

TITANICHTHYS AGASSIZII NEWBERRY

The infero-gnathal plate of *Titanichthys agassizii*, when viewed edgewise (Fig. 1, B-D), is bent in a nearly uniform arc of slightly less than 90 degrees. The sides of the element are, therefore, 1 longitudinally convex face (x), and 1 longitudinally concave face (y). Measured along the curvature of the convex face, the bone possesses an extreme length of approximately 100 cm. Its actual length in a straight antero-posterior line is 73 cm.

As in other Arthrodira, the element exhibits the divisions which have been called generally the functional and blade portions, terms which are employed throughout this paper also. In approximate extent the former division (Fig. 1, A-C, I) occupies the anterior third, and the latter division (II) the posterior two thirds of the bone. As may be seen from the aspect of either the convex or concave face (Fig. 1, A or C, respectively) these parts are bent in opposite directions, vertically, and their margins are given posteriorly diverging, sigmoidal contours. Thus, 1 margin (Fig. 1, A-C, a-b-c) is concave on the blade, and convex on the functional part. The opposite margin (Fig. 1, C, c-d-e) is, conversely, concave on the anterior functional portion of the element, and convex on the posterior blade. The curvatures of these 2 margins are not equal, those of the latter being more pronounced.

In addition to this bending in opposite vertical directions, the 2 divisions of the bone lie in different transverse planes. In a cranial view of the figured example, therefore, the blade appears to be twisted clockwise on the longitudinal axis of the functional portion.

The blade portion has its greatest vertical and thinnest transverse expansion posteriorly. Anteriorly this maximum depth is gradually diminished by one half in the region where the blade and functional parts are joined. Accompanying the anterior decrease in height, the blade exhibits also a progressive thickening, which is carried forward into the posterior half of the functional part adjacent to the concave face.

[1]Claypole, E. W., (A. A. Wright, MS.), Rep. Geol. Surv. Ohio, Vol. VII, 1893, p. 612, pl. XLII, figs. 1-2.

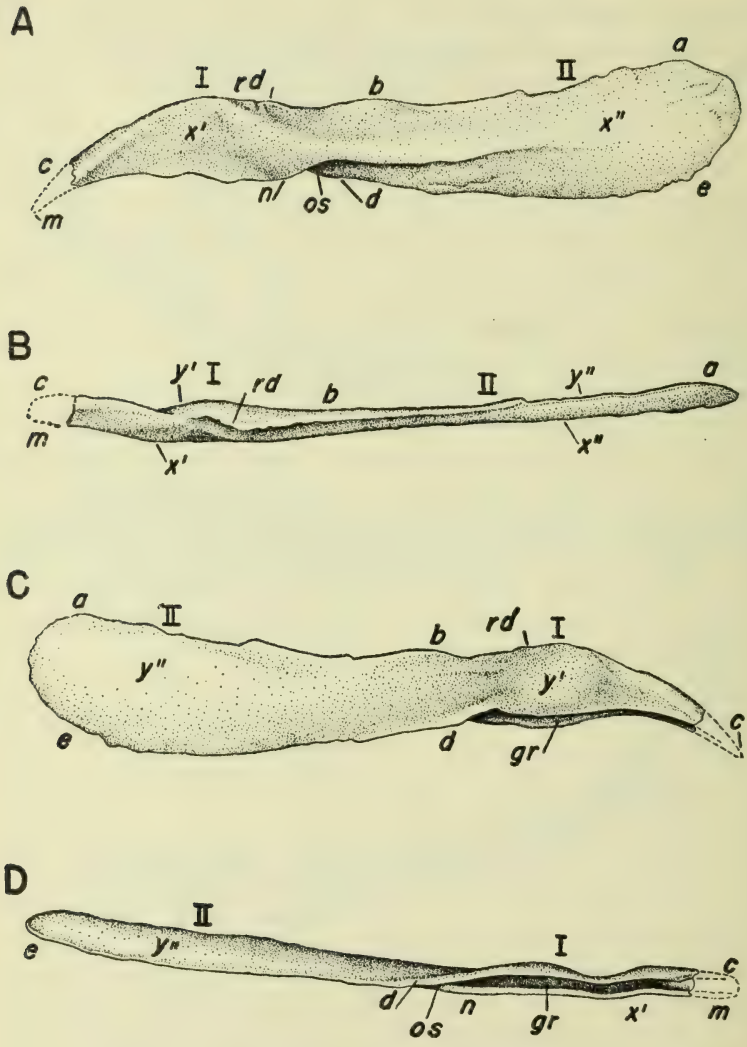

FIGURE 2.— *Titanichthys clarkii* Newberry (C. M. N. H. No. 5002). Left infero-gnathal plate in (A) lateral, (B) dorsal, (C) mesial, and (D) ventral views. Reproduction approximately x 1/7.

Explanation of Symbols. — *x'-x''*, lateral convex and concave faces, respectively, of the functional and blade divisions; and *y'-y''*, lingual concave and convex faces, respectively, of the functional and blade divisions; others as in Figure 1.

The functional division, in its posterior half, is low but rather heavily developed. By reason of the forward convergence of the margins, its anterior half is produced into a wide, spatulate extremity. On the convex side of the bone (Fig. 1, A, x), the functional portion is markedly convex in transverse section. In similar section, the concave side (Fig. 1, C, y) is but slightly concave.

The concave margin of the blade (Fig. 1, A-B, a-b) extends along the entire convex border of the functional portion, next to the concave side of the element (y), in the form of a low, rounded ridge (rd). This gives the impression of a shallow longitudinal depression, which, except on the spatulate extremity, merges imperceptibly into the rounded surface of the convex face.

The convex margin of the blade (Fig. 1, C-D, d-e) because of the transverse twisting of the blade on the functional portion, seems to cross the main axis of the bone diagonally. It is carried forward to the tip of the produced extremity (c), and bounds, adjacent to the concave face, a deeply excavated groove (Fig. 1, D, gr) occupying the concave margin of the anterior division. This groove, on its other side, is limited by the projecting edge of the vertically rounded convex face (Fig. 1, A-D, m-n). This latter margin extends posteriorly to merge with the blade on its convex side. Through the offset (Fig. 1, A-D, os) thus produced, the groove is seen to open on the convex side of the infero-gnathal plate, behind the functional portion.

The figured specimen exhibits a relatively thin sheet of tissue (Fig. 1, C-D, AIG) crushed into the groove on the concave margin of the functional division. This consists of bone presumably identical with any other Titanichthyid plate histologically, except that it is possibly more cancellous. The observance of a similar but somewhat displaced structure is undoubtedly responsible for Claypole's[2] belief in the presence of 'teeth' on the infero-gnathal elements of *Titanichthys*. Although rarely observed, this bony tissue probably represents a heretofore inadequately known element in the Arthrodiran skeletal complex, which normally occupied the groove. The reasons for this supposition and their significance will be discussed below.

[2]Claypole, E. W., Amer. Geol., Vol. XII, 1893, pp. 89-99.

TITANICHTHYS CLARKII NEWBERRY

The infero-gnathal plate of *Titanichthys clarkii*, when viewed edgewise (Fig. 2, B-D), does not exhibit the longitudinally crescentic shape possessed by that of *T. agassizii*. Although practically always crushed flat in preservation, the general contours of both its sides show evidences of normal sigmoidal habits. Consequently on the side of this element in *T. clarkii* which corresponds to the convex side (Fig. 1, A-B, x) in the preceding species, only the face of the functional portion is convex (Fig. 2, A-B, x′). The posterior extension of this face as the side of the blade is slightly concave (Fig. 2, A-B, x″). A reversal of these curvatures is, of course, found on the opposite side, which corresponds to the concave face of the *T. agassizii* infero-gnathal plate (Fig. 1, B-C, y). Here only the face of the functional portion is concave (Fig. 2, B-C, y′), and this side of the blade is very slightly convex (y″). The total length of the bone is approximately 66 cm.

As indicated above, the element exhibits the usual differentiation into functional (Fig. 2, A-C, I) and blade (II) portions, which possess about the same proportional extent found in *T. agassizii*. The various margins in their form and in their relationships to the other structural features closely agree with their homologues in the latter species. Accordingly, it has been possible to label the figures of the infero-gnathal plate of *T. clarkii* identically with those of *T. agassizii*. The direct comparisons, thus facilitated, render further detailed text descriptions unnecessary.

Aside from the differences noted above, several additional ones will be observed between the infero-gnathal plates of the 2 species. These are, in the main, merely proportional variations and have been previously employed by Newberry[3] and others as specific characterizations. In this connection it is perhaps worth while to remark that the *T. clarkii* plate displays a more pronounced vertical curvature of the blade part. In addition, both its blade and functional portions possess greater proportional depth. Finally, it deserves to be pointed out that the element is relatively thinner throughout.

The bony tissue (Fig. 1, C-D, AIG), which occupied the groove on the concave margin of the functional portion in *T. agassizii*,

[3]Newberry, J. S., Mon. U. S. Geol. Surv., XVI, 1889, pp. 340, pls. I-LIII, text figs. 1-3.

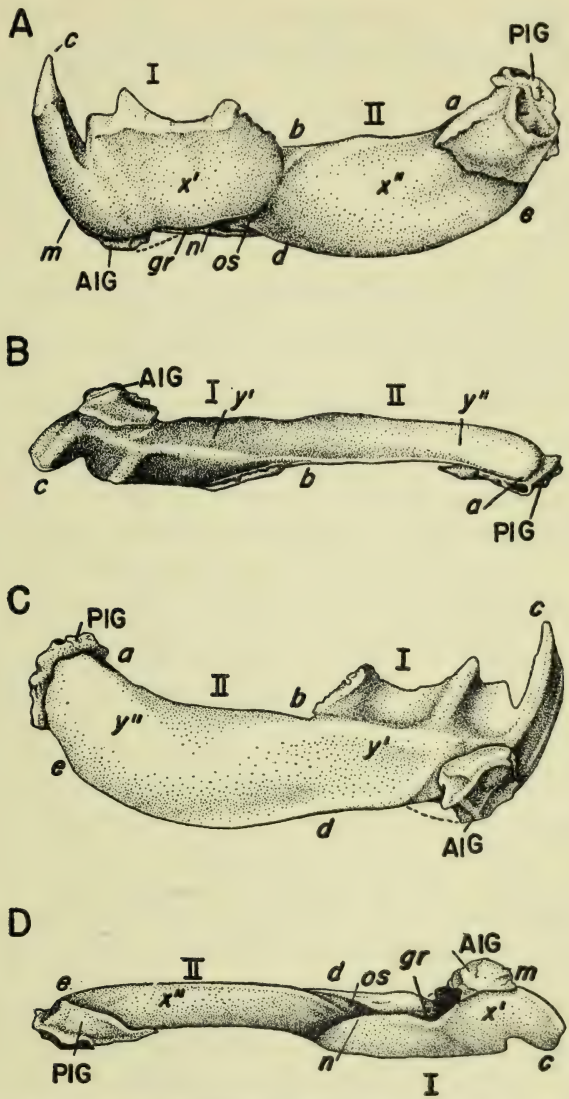

FIGURE 3.— *Dinichthys intermedius* Newberry (C. M. N. H. No. 7054). Left infero-gnathal plate in (A) lateral, (B) dorsal, (C) mesial, and (D) ventral views. Reproduction approximately x 1/7.

Explanation of Symbols. — PIG, postero-infero-gnathal plate; others as in Figures 1 and 2.

was not preserved in any examined specimen of *T. clarkii* from the Cleveland Shale. However, such an element was found on an infero-gnathal plate of the *clarkii* type from the Huron Shale phase of the Ohio Shales in southern Ohio. The latter specimen (Fig. 4) displays the extra element displaced backward from its position in *T. agassizii*, described above, and here lies across the offset on the convex side of the element, half in the marginal groove and half on the face of the blade.

COMPARISON OF *TITANICHTHYS* WITH *DINICHTHYS*

To the present writers' knowledge neither bony tooth-like denticles nor worn areas due to the oppositional wear by supra-gnathal elements have ever been observed on the infero-gnathal plates of *Titanichthys*. It is perhaps pertinent, in this regard, that aside from the single report by Hussakof[4], the supra-gnathal plates of this genus are unknown. Despite this absence of either 'teeth' or areas of wear which might conclusively prove their correct orientation, the lower mouth parts of *Titanichthys*, always unquestioningly, have been interpreted with the convex face (Figs. 1 or 2, x or x′-x″, respectively) as lateral, and the concave face (y or y′-y″) as lingual. Accompanying this identification of sides, the longitudinally and deeply grooved concave margin of the functional portion (Figs. 1-2, D) was considered to be the oral border. As a consequence, the produced anterior extremity of this part projected forward dorso-mesially. It follows likewise that the vertically curved blade was arched downward posteriorly, with its convex margin (Figs. 1-2, d-e) dorsally, and its concave edge (a-b) ventrally, situated.

By these criteria, the figured plates of *T. agassizii* and *T. clarkii* must be from the right side. However, a number of difficulties were immediately encountered when the attempt was made comparatively to analyze these bones, point by point, in relation to the corresponding elements from the right side of *Dinichthys*, *Stenognathus*, or any form in which there is no question of orientation. Quite contrarily, by turning the Titanichthyid infero-gnathal plates over, as figured, and comparing them with the left lower mouth parts from these latter unquestioned forms, it is possible to match every structural feature except in those characters which are definitely

[4]Hussakof, L., Bull. Geol. Soc. Amer., 1930, Vol. XLI, p. 196.

and peculiarly generic differentiations. To illustrate these points, a left infero-gnathal plate of *Dinichthys intermedius* Newberry is figured here (Fig. 3).

In any frontal section, the Dinichthyid element will exhibit sigmoidal contours of its sides. These contours are contributed to by the transverse twisting (clockwise in the case of an example from the left side) of the blade on the functional portion. In the main, however, they result from the bending of the functional part toward the median line, anteriorly, and by the opposite lateral bending of the blade, posteriorly. The lateral face of the functional portion is, hence, longitudinally convex, and that of the blade, in less degree, concave. Conversely, the lingual side of the functional part is concave, and the corresponding face of the blade slightly convex. The x′-x″ face of *T. clarkii* (Fig. 2, A-B) thus appears to be similar to the lateral side of the Dinichthyid infero-gnathal plate (Fig. 3, A-B), as does also the y′-y″ face to the lingual side of the latter. This is presumed to indicate that the previous determination of sides in the Titanichthyid element is correct.

The longitudinal groove occupying the ventral margin of the anterior division in *Dinichthys* is, in several respects, very suggestive of the longitudinal groove always present on the concave margin of this part in *Titanichthys*. The points of similarity are, namely, that the groove in both types is limited on the convex or lateral side (x or x′-x″) by the projecting edge of this face (Figs. 1-2-3, A-D, m-n), and that it opens on this side behind the functional portion, in both types through the offset (os) produced by the backward extension of the laterally limiting wall (m-n) onto the face of the blade. As described above, the bounding ridge of the groove on the concave or lingual side (y or y′-y″) in *Titanichthys* is formed by the anterior continuation of the convex margin of the blade (d-e), crossing diagonally the main axis of the bone. Although the same conditions apparently obtain in *Dinichthys*, it must be pointed out that the structural details in this regard are difficult of comparison. This results from a great thickening of this mesial wall of the ventral groove in the latter form, perhaps coincident with its predatory adaptations.

A small element (Fig. 3, AIG) is often found appressed to the lingual face of each infero-gnathal plate at the symphysial region,

in the more nearly complete and better preserved specimens of *Dinichthys*. This bone is triangular in cross section, and may be roughly likened to a tetrahedron. Its lateral face is in contact with the mesial face of the infero-gnathal. The dorsal face is broad anteriorly and shows that the infero-gnathal plates from either side were normally and widely separated from each other in front. The mesial face is convex in both transverse and frontal sections. This surface is variously pitted and ridged, suggesting close ligamentous connections with its fellow from the opposite side. Finally, a fourth face, in greater or lesser confluence with both the dorsal and mesial faces, is directed inward, postero-ventrally. The element gradually tapers in diameter postero-laterally, and this portion, although missing in the figured specimen, occupies the anterior portion of the ventral groove. Claypole[5] apparently suspected the presence of these bones, but without description or specific mention of the evidence, he merely referred to them as 'inter-mandibular' plates. Here, in conformity with accepted Arthrodiran terminology, the present writers propose the rather cumbersome name of antero-infero-gnathal plates.

These elements can not be distinguished histologically from any other bone in the skeletal complex of *Dinichthys*. They and the postero-infero-gnathal plates described by Heintz[6], are assumed, nevertheless, to be anterior and posterior ossifications, respectively, of Meckel's cartilage. As such, they would substantiate the current views on the gnathostomatous nature of the Placoderm mouth parts[7]. In view of so probable a basic organization of the Arthrodiran visceral skeleton, the thin cancellous bone that lies in a structurally comparable groove on the Titanichthyid infero-gnathal, would appear to be homologous with the antero-infero-gnathal plate of *Dinichthys*. The presence of this element thus offers additional support to the present interpretation that the grooved concave margin of the functional portion in *Titanichthys* is ventral.

With this identification of sides and this determination of the ventral margin, the vertically curved blade of the Titanichthyid element arches upward posteriorly. Thus as in *Dinichthys*, the concave edge (a-b) is dorsal and the convex margin (d-e) is ventral.

[5]Claypole, E. W., Amer. Geol., Vol. X, 1892, p. 193.

[6]Heintz, A., Bashford Dean Mem. Vol., 1932, Art. 4, pp. 111-260, pls. I-IX, text figs. 1-19.

[7]Stensiö, E. A., Medd. om Grönl., Bd. LXXXVI, 1931, No. 1, pp. 1-212, pls. I-XXXVI, text figs. 1-95. Watson, D. M. S., Philos. Trans. Roy. Soc. London, Series B, Vol. CCXXVIII, No. 549, October, 1937, pp. 49-146, pls. V-XIV, text figs. 1-25.

The formidable anterior cusp and laterally disposed shearing flange of *Dinichthys* obviously has no counterpart on the infero-gnathal plate of *Titanichthys*. By the present interpretation, however, the convex margin of the functional portion is the dorsal, oral border, and the produced anterior extremity is directed downward, antero-mesially. This arrangement seems suggestive of a ventrally opening and sub-terminal mouth, possibly in adaptation to a bottom feeding mode of life. Such a view is by no means inconceivable, and a number of additional characters are displayed by Titanichthyids which must be considered to support this opinion. The general dimensions of their bones reflect the huge size attained by these forms. When this size is coupled with the exceedingly broad and dorso-ventrally flattened head, a body shape may be visualized which is commonly associated with fishes of rather sluggish movements. Further, it is implied that *Titanichthys* fed on soft substances, since the lack of worn areas on its infero-gnathal plates possibly indicates weak upper jaw parts; and since the persistent absence of rostral plates, which leaves a large median vacuity in the cranial shield, suggests a soft and flexible upper lip.

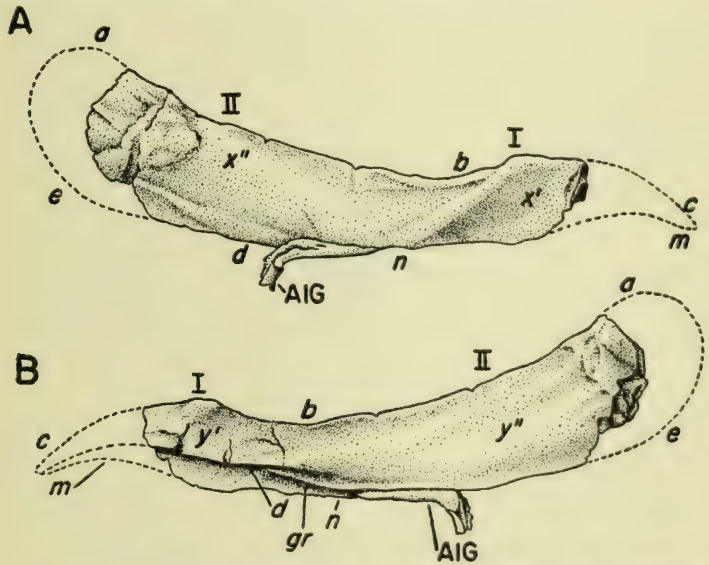

FIGURE 4.— *Titanichthys* (*clarkii*?) (C. M. N. H. No. 7366). Right infero-gnathal plate in (A) lateral, and (B) mesial views. Reproduction approximately x 1/7.

For explanation of the index symbols refer to Figures 1 and 2.

A NEW FOSSIL FISH OF THE FAMILY LEPTOLEPIDAE

By
David H. Dunkle

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Vol. VIII | Issued, May 29, 1942 | No. 5

A NEW FOSSIL FISH OF THE FAMILY *LEPTOLEPIDAE*

BY
David H. Dunkle

The new fish here described was first recognized from a single specimen which is associated with the small assemblage of *Pholidophorus americanus* Eastman remains reported by Schoewe[1] from a horizon in the Upper Lykins formation of Colorado. Subsequent search revealed a number of identical fishes similarly included among collections of *Pholidophorus americanus* from localities in New Mexico to which Koerner[2] has called attention.

Although little more than a darkened impression on a relatively coarse sandstone matrix, the one specimen from Colorado distinctly shows undivided, ring-like vertebral centra, the presence of intermuscular bones, and an absence of fulcral scales. The fishes from the occurrences in New Mexico are generally better preserved, and in addition to the features noted above, exhibit an unmodified condition of the haemal arches supporting the equilobate caudal fin, and evidences of a thin covering of ganoin on the bones of the head. The combination of these structural characteristics is taken here to be indicative of a member of the isospondylous family Leptolepidae. It is of especial interest, therefore, as only the seventh reported occurrence of a Leptolepid in the whole of the western hemisphere[3].

I am indebted to Dr. Claude W. Hibbard for granting me the privilege of making this study. A number of specimens belonging to several museums has been generously loaned for examination. For these courtesies I wish to express my appreciation to the officials of the Museum of Comparative Zoölogy, Harvard University; to Dr. Hugo G. Rodeck of the Colorado University Museum; and to Dr. E. C. Case of the Museum of Paleontology, University of Michigan. Finally, I tender my sincere thanks to Mr. William C.

[1]Bull. Geol. Soc. Amer., Vol. XLI, No. 1, 1930, p. 203 (abstract).

[2]Amer. Journ. Sci., Ser. 5, Vol. XIX, 1930, p. 463.

[3]The 6 previously reported western hemisphere occurrences of Leptolepids are from Patagonia (Erasmo, Atti R. Acc. Sci. Fis. e Nat. Napoli, Ser. 2, Vol. XX, No. 8, 1934, 26 pp. 1 pl.); Argentina (Cabrera, Revista del Museo de la Plata, Vol. XXX, 1927, pp. 317-319, 1 text fig.); Brazil (Jordan and Branner, Smithson. Misc. Coll., Vol. LII, 1908, pp. 1-29, pls. 8, text figs. 22); Cuba (Gregory, Bull. Amer. Mus. Nat. Hist., Vol. XLVIII, 1923, pp. 223-242, text figs. 6); Mexico (Felix, Paleontogr., Vol. XXXVII, 1891, pp. 140-194, pls. XXII-XXX); and from the United States (David, Journ. Paleont., Vol. XV, No. 3, 1941, pp. 318-321).

Darrah, Harvard University Botanical Museum; to Dr. Reginald G. Fisher, Secretary, Science Commission of New Mexico; and to Dr. Theodore E. White, Museum of Comparative Zoölogy, Harvard University, for their ready responses to various questions.

Leptolepis schoewei, sp. nov.[4]

Diagnosis.— Differs from all known members of the genus in having an exceptionally weak vertebral development; a distal fusion of the right and left halves of the neural arches in the abdominal region; an apparent lack of supraneural elements; a loose articulation between the vertebral centra and the neural and haemal structures; enlarged ridge scales both dorsally and ventrally at the base of the caudal fin; and a larger anal fin.

Description.— A slenderly fusiform fish, not known to exceed 56 mm. in length from snout to posterior margin of the caudal fin emargination. Head large, its length with the opercular apparatus occupying slightly less than one third the length of the fish to the base of the caudal fin, and its depth, which approximates the maximum body depth, contained about 4 times in this body length. Bones of the head unknown, but indicated to have been delicately enamelled. Orbit centrally placed, its diameter equal to one third the length of the head and opercular apparatus. Suspensorium vertical or but slightly inclined forward. Mouth terminal, somewhat uptilted, apparently edentulous, and with wide gape. Premaxillary small. Maxillary in 2 parts: a short, thick, constricted anterior portion, and a long, thin, blade-like posterior portion with convex oral border. Mandible deep, and exhibiting a marked oral elevation shortly behind the symphysis. Opercular series complete, with none of the component elements modified, but typical in form and arrangement. A relatively large median gular plate present. Vertebral centra in the form of undivided, ring-like cylinders, their depth 3 times their length, and most commonly developed only in the caudal region. Neural structures of the caudal region more heavily developed than those of the trunk portion, and possessing strong proximal expansions. Haemal arches similar in development to the posterior neurals, those supporting the caudal fin not fused. All the neurals and haemals articulating freely with the vertebrae. No supraneural elements observed. Short, fine intermuscular bones present, lying across the neural arches in the abdominal region, anterior to the origin of the dorsal fin. Ribs thin, gently arched, and reaching quite or nearly to the ventral body margin. Dorsal fin apparently as long as deep, with 15 (?) lepidotrichia and a corresponding number of short, delicate proximal radial supports, forwardly

[4]Named in honor of Dr. Walter H. Schoewe, who discovered the holotype.

placed opposite the pelvic fins or the space between the anal fin and the pelvics. Caudal equilobate and deeply cleft, with 17 irregularly articulated rays; the foremost long ray on both dorsal and ventral lobes not bifurcated, preceded by 8 short rays and an enlarged ridge scale above, and by 7 short rays and an enlarged scale below. Anal fin similar in size and in number of rays to the dorsal; proximal radial supports somewhat longer and heavier. Pectoral and pelvic fins of about equal size, the former with more than 13 rays, the latter abdominal, and with 11-14 rays. None of the fins with fulcral scales.

Measurements.—Total length of holotype, from snout to posterior margin of caudal fin emargination, 39 mm.; length to base of caudal fin, 36; length of head from snout to posterior border of operculum, 11; greatest depth of head, 8; body depth at base of caudal fin, 3. These same measurements of specimens in the series at hand range respectively from 33-56 mm.; 30-51; 11-17.5; 8.5-12 plus; and 3-6.

Holotype.— No. 784, Kans. Univ. Mus. Vert. Paleont.; a complete but imperfectly impressed fish in counterpart; from the Lower Jurassic (?) in the Upper Lykins Formation on Felch Creek, 15 miles north of Canyon City, Colorado; collected in summer, 1925, by Walter H. Schoewe.

Referred Material.— In addition to the holotype, 7 specimens (Nos. 17469 a-b, Colo. Univ. Mus.; Nos. 11217, 12953, 12954, Univ. Mich. Mus. Paleont.; No. 7190, Mus. Comp. Zoöl.; No. 8218, Cleve. Mus. Nat. Hist.), all from the base of the Wingate sandstone, near Ima, in both Guadalupe and Quay Counties, New Mexico.

Remarks.— In the form and disposition of the fins, and in general body proportions, the present form seems more closely affined to *Leptolepis* and its presumed allies than to *Thrissops* and its related genera[5]. Of these, *Leptolepis schoewei* differs from *Tharrhias* chiefly in the structure of the opercular series; and from *Manchurichthys*[6] in the greater number of vertebrae, the larger size of the anal fin, and the presence of the abruptly developed oral elevation on the dentary. This mandibular process, which also serves to distinguish the present form from *Anaethalion*, is structurally similar to the condition of the same part in true *Leptolepis* and has led to the present inclusion of this species in that genus. The finer morphological details are obscure in all the specimens at hand. Among observable characteristics, however, are the marked differences between *L. schoewei* and the more typical species of *Leptolepis*, which already have been noted in the diagnosis. It may be fairly stated that the true signifi-

[5]Woodward, Catalogue Fossil Fishes British Museum, Pts. III-IV, 1895-1901.

[6]Saito, Rep. 1st Scient. Exped. Manchoukuo, Sec. II, Pt. III, 1936, pp. 1-23, pls. I-V, text figs. 2.

cance of such differences is not clear. Thus, the present generic reference, perhaps, may be better considered as provisional until a critical analysis of the entire family Leptolepidae shall have been made, which Dr. Theodore E. White and I propose to undertake in the near future.

The manifest distinctions between *Leptolepis euspondylus* Gregory[7] and *Leptolepis schoewei* will be brought out in a forthcoming paper by Dr. White, who is studying the magnificant series of the Cuban form in the Museum of Comparative Zoölogy.

In age, the Colorado Upper Lykins horizon has been referred to the Lower Jurassic[8]. That this fossil level is no younger, and perhaps may be somewhat older, seems partially substantiated by 2 facts.

First, a gymnosperm cone found with the fish specimens from Colorado was submitted to William C. Darrah of the Harvard University Botanical Museum for identification, and he has kindly written to me concerning it as follows:—"It is not possible to identify this strobilus to species because cellular structure is not preserved, and because, in my opinion, it is probably new. It belongs clearly to a group of plants known as the Voltziales and probably to the genus *Palissya*. *Palissya* occurs in both the Triassic and Jurassic of various portions of the world . . . Under ordinary circumstances, the genus is characteristic of Rhaetic rocks. However, I must make a qualifying statement concerning the specimen in hand which is No. 924a, Kans. Univ. Mus. Vert. Paleont. This is the fact that the small cone has not more than a dozen scales which are of slightly different shape than the typical species of *Palissya*, and indeed resembles more the true genus *Voltzia*, which occurs all the way from the basal Permian to the Upper Triassic. We may both be confident that the plant is of Lower Mesozoic age. On the basis of the single specimen it is difficult, however, to adduce more data than this."

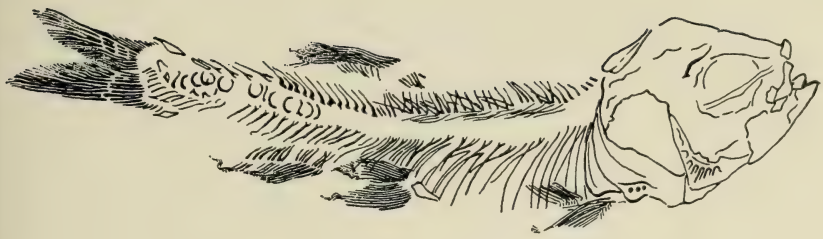
Second, Koerner[9] reported that the thin carbonaceous limestone in New Mexico that contains the identical piscine fauna, overlies, unconformably, the Triassic Dockum group of sediments, and is overlain by the Wingate sandstone. According to the correlations of Baker, Dana, and Reeside[10], the Wingate sandstone is only provisionally placed in the Lower Jurassic. Therefore, should this latter ultimately prove to be Upper Triassic, as suggested, the age of the fish bearing stratum would necessarily be revised downward also.

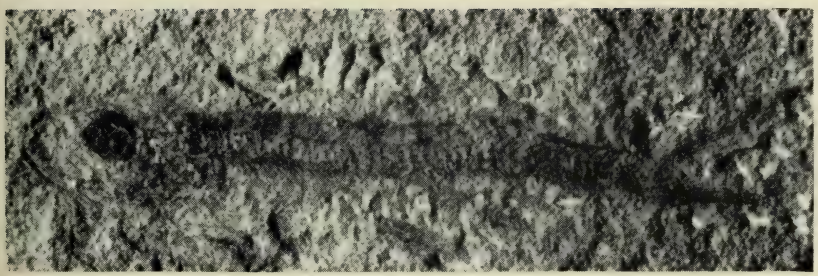
[7]Gregory, Bull. Amer. Mus. Nat. Hist., Vol. XLVIII, 1923, pp. 223-242, text figs. 6.

[8]Schoewe, Bull. Geol. Soc. Amer., Vol. XLI, No. 1, 1930, p. 203 (abstract).

[9]Amer. Journ. Sci., Ser. 5, Vol. XIX, 1930, p. 463.

[10]Prof. Pap. U. S. Geol. Surv., No. 183, 1936, pp. I-VI, 1-66; pls. I-XXVI; tables 1-8; text figs. 1-16.





Leptolepis schoewei Dunkle. Above, sketch showing the habit of entire fish (No. 17496a, Colo. Univ. Mus.). Reproduction approximately x 1.9. Below, photograph of the holotype (No. 784, Kans. Univ. Mus. Vert. Paleont.). Reproduction approximately x 2.3.

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Vol. VIII ISSUED, JUNE 23, 1942 No. 6

A NEW GENUS AND SPECIES OF ARTHRODIRA FROM THE CLEVELAND SHALE

BY
DAVID H. DUNKLE
AND
PETER A. BUNGART

Among the prepared Arthrodiran specimens from the Cleveland Shale in the collections of the Cleveland Museum of Natural History are several infero-gnathal plates of a form the characters of which are so distinct that we deem it worthy of description as a new genus and species. For this new Arthrodire we propose the generic name *Holdenius*, in some trivial and belated expression of gratitude for the great interest and generous support always given by Mr. Guerdon S. Holden to geological and paleontological studies at the Cleveland Museum of Natural History.

Holdenius, gen. nov.

Diagnosis.— A Dinichthyid Arthrodire which differs from its closest relative *Heintzichthys*[1] in such characters of the infero-gnathal plate as the greater average depth of the element in proportion to its total length; the seeming shortness of the functional portion ventrally; the greater thickness of the dorso-lateral oral flange on the functional division in proportion to the maximum thickness occurring near the antero-ventral margin of the bone; the dorso-lateral flange worn by the opposing postero-supra-gnathal at most, insofar as known, only on the anterior two thirds; and the unworn posterior third of the oral border exhibiting a single row of minute denticles bent inward at right angles to the external face of the plate.

Genotype.— *Holdenius holdeni*, sp. nov.[2]

[1]Whitley, Copeia, No. 3, 1933, p. 146.
[2]Named also for Mr. Guerdon S. Holden.

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Holdenius holdeni, sp. nov.

Diagnosis.— The same as for the genus (the only species).

Description.— Although smaller than either of the two additional referred specimens are indicated to have been, the type left inferognathal plate of *Holdenius holdeni* is alone described here because of its greater completeness. This element measures 50 cm. in total length, and exhibits a remarkably straight longitudinal axis without evidence of extreme crushing or other distortion during preservation. Thus, it must have been so situated in the mouth that the external and internal faces were directed, respectively, antero-laterally and postero-mesially. Except for the high anterior cusp the plate is almost uniformly expanded vertically throughout its length, and the average of this depth is contained about 5 times in the total length.

Characteristically Arthrodiran, the bone is composed of posterior blade and anterior functional portions, whose general configurations may be seen in the accompanying drawings (Fig. 1, A and B; Fig. 2, B). The blade is a relatively thin lamina which is but slightly uptilted postero-laterally. Its consequently gently concave dorsal margin occupies one half the entire length of the bone. For reasons described below, the convex ventral margin of the blade appears notably longer than the dorsal in lateral view (Fig. 1, A), and approaches three quarters of the total length.

Mesially (Fig. 1, B), the transition between the blade and functional portions is not apparent. Forward from the middle longitudinal point near the dorsal margin, the main shaft of the element as shown by the lingual face of the blade gradually diminishes in depth with an accompanying increase in thickness. The maximum transverse breadth is attained near the antero-ventral extremity, and gives the only impression of any mesial curvature in the symphyseal region shown by the element. In this lingual aspect, a distinct, but narrow shelf is exhibited which results from the merging of the oral flange laterally on the heavier, more ventral portion of the functional division.

Laterally (Fig. 1, A), because of its greater thickness, the functional portion appears to be situated in a more external plane. The limit of this greater thickness is well marked postero-ventrally by

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an offset which extends from the mid-dorsal longitudinal point antero-ventrally. The acuteness of the angle in which this offset is carried across the external face of the infero-gnathal plate gives the functional portion of the element an extremely short antero-posterior length ventrally, and accounts for the apparent great length of the ventral margin of the blade referred to above. Posteriorly, the face of the functional division is almost flat both longitudinally and vertically. Anteriorly, it is very slightly convex in either transverse or horizontal section.

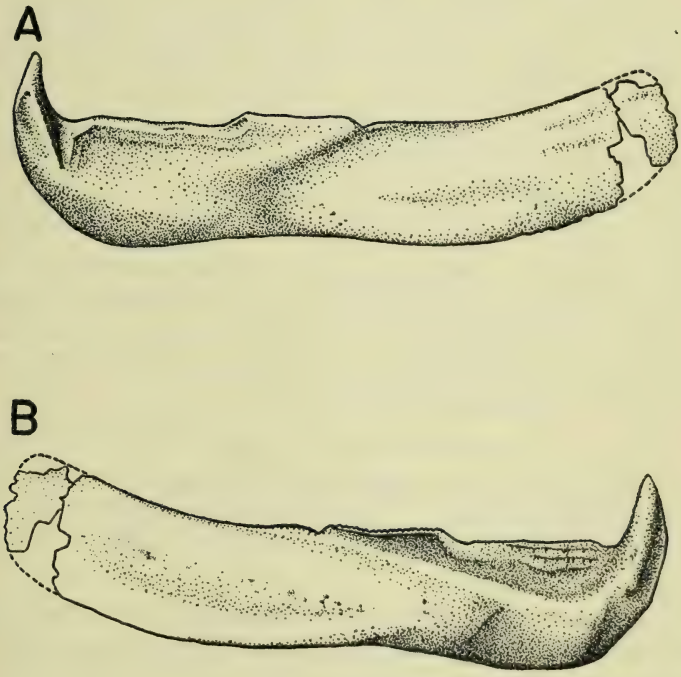

FIGURE 1.—*Holdenius holdeni* Dunkle and Bungart (No. 6130, C.M.N.H.). The type left infero-gnathal plate in (A) lateral, and (B) mesial views. Reproduction slightly less than x 1/6.

In a direct continuance of the maximum thickening attained near the antero-ventral extremity, the anterior margin of the plate is produced into a heavy, dorsally projecting cusp. This structure is subtriangular in section with its vertical, apical ridge directed mesially. A deep V-shaped groove worn by the antero-supra-gnathal bone separates the anterior cusp from the posteriorly succeeding dorso-lateral flange. This latter portion of the oral margin is characterized by its length, and by its general uniform thickness which equals one half the greatest transverse breadth possessed by the element, and must, therefore, be considered as extremely robust in relation to the proportions of the same parts shown by other Arthrodires. In addition it is but little higher than the dorsal edge of the blade, and may be said to be almost perfectly horizontal in either internal or external views. Although conceivably subject to age, only the anterior two thirds of the oral flange is worn by the opposing postero-supra-gnathal plate in all the specimens at hand. The worn edge is very obtuse and when the plate is held upright seems more adapted for crushing than for shearing. The dorsal border of the unworn posterior third of the flange is set with a single row of minute tubercles averaging 1 mm. in height, which are incurved at right angles to the external face of the bone.

No well-marked ventral groove on the functional division of the plate so typical of other Dinichthyids can be observed. However, a broad, shallow sulcus on the antero-mesial face at the base of the anterior cusp indicates the area of articulation for the antero-infero-gnathal element recently described.[3]

Holotype.—A complete left infero-gnathal plate, No. 6130, Cleve. Mus. Nat. Hist.; from the upper Devonian Cleveland Shale on the Northwest Branch of Big Creek (Berea Quadrangle), Cuyahoga County, Ohio; collected, September 17, 1931, by Peter A. Bungart.

Referred Specimens.— In addition to the type, (1) No. 5346, Cleve. Mus. Nat. Hist.; a right infero-gnathal plate lacking portions of the anterior cusp and the posterior extremity of the blade; from the upper Devonian Cleveland Shale on the Northwest Branch of Big

[3]Scient. Publ. Cleve. Mus. Nat. Hist., Vol. VIII, No. 4, May 1, 1942, pp. 48-59, text figs. 1-4.

Creek (Berea Quadrangle), Cuyahoga County, Ohio; collected, July 21, 1925, by Peter A. Bungart. (2) No. 5277, Cleve. Mus. Nat. Hist.; a fragment of the denticulated posterior portion of the oral flange and fragments of two undetermined plates; from the upper Devonian Cleveland Shale on Big Creek (Berea Quadrangle), Cuyahoga County, Ohio; collected, March 28, 1925, by Peter A. Bungart.

Remarks.— The infero-gnathal plate of *Holdenius holdeni* varies markedly in many structural details from the corresponding elements of all Cleveland Shale members of the genus *Dinichthys*, of which *Dinichthys intermedius* may be considered a typical example (Fig. 2, D). The most important of these differences, however, lies in the condition of wear of the oral margin, because this feature among the Dinichthyid Arthrodires is indicative of the type of opposing supra-gnathal elements. The acutely beveled, shearing margin in the Cleveland Shale *Dinichthys* is always associated with an antero-supra-gnathal bone whose dorso-lateral extremity is incurved and greatly expanded for direct abutment against an as yet undescribed basicranial plate. The obtusely beveled, crushing type of oral margin that is possessed by *Heintzichthys* and *Gorgonichthys* (Fig. 2, A and C, respectively) is associated with antero-supra-gnathal elements whose dorso-lateral extremities are produced only posteriorly as relatively thin laminae for an overlapping articulation with a homologous but extremely different type of basicranial plate. For these reasons, although the antero-supra-gnathal of *Holdenius* is unknown, it seems, nevertheless, safe to infer that this genus is affined to the latter 2 genera.

The great differences between *Holdenius* and *Gorgonichthys*[4] (Fig. 2, B and C, respectively) are apparent without discussion. On the other hand, that *Holdenius* and *Heintzichthys* (Fig. 2, B and A, respectively), are more closely related is indicated by their common possession of infero-gnathal plates which exhibit a remarkable longitudinal straightness in both the horizontal and vertical planes, and on which the dorso-laterally disposed oral flange is of exceptional length and uniform lowness. The differences in structural

[4]Scient. Publ. Cleve. Mus. Nat. Hist., Vol. VIII, No. 3, Oct. 8, 1940, pp. 29-47, pls. IV-V, text figs. 1-7.

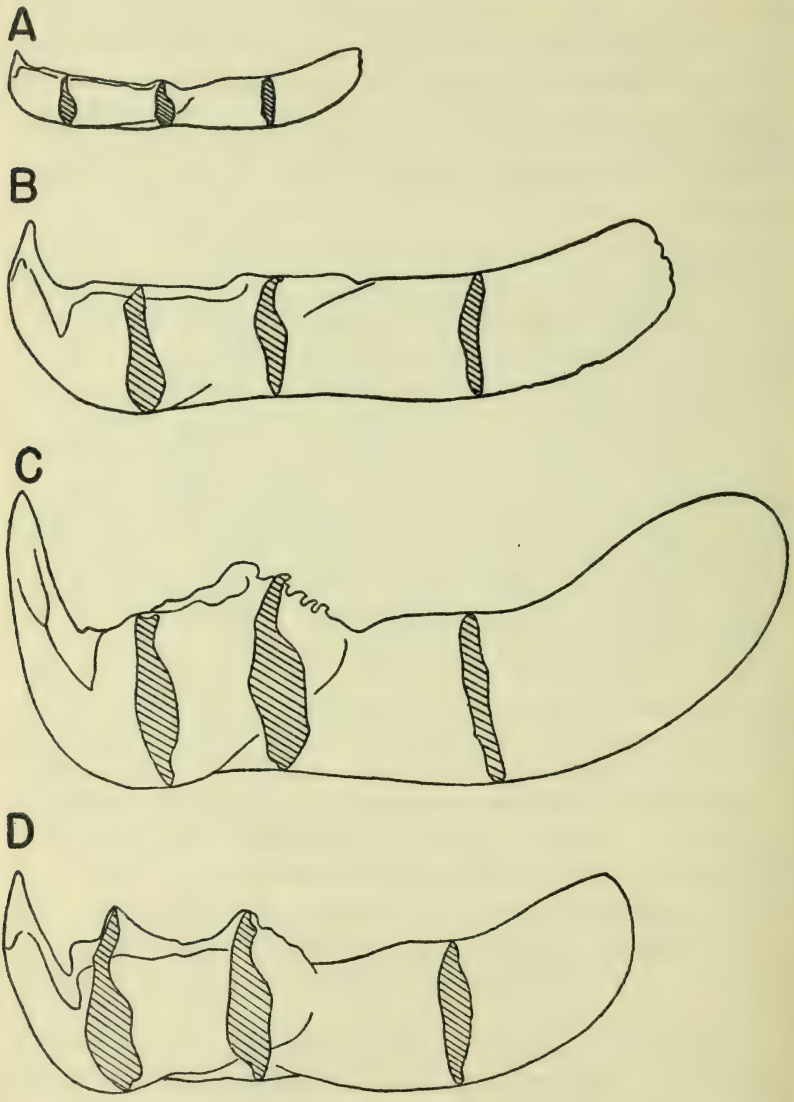

FIGURE 2.— Outline sketches of the left infero-gnathal plates of (A) *Heintzichthys gouldii;* (B) *Holdenius holdeni*; (C) *Gorgonichthys clarki;* and (D) *Dinichthys intermedius;* with corresponding transverse (shaded) sections superimposed on each to show the relationships and proportions of parts. Reproduction slightly less than x 1/6.

details and in the proportion of parts between the two, that are listed in the generic diagnosis, are, however, most striking on direct comparison; and of the proportions it may be further stated that their degree of difference is far greater than our present knowledge permits us to expect within any described genus of Cleveland Shale Arthrodira. The present generic separation from *Heintzichthys* on the basis of lower mouth parts will undoubtedly be verified when future discoveries of more complete *Holdenius* remains are made.

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COMMENTS ON DIPLOGNATHUS MIRABILIS NEWBERRY

BY
DAVID H. DUNKLE
AND
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The arthrodiran fish *Diplognathus mirabilis* was defined by Newberry[1] in 1878. The original description was based on the anterior half of one infero-gnathal plate collected in the upper Devonian Cleveland Shale of Lorain County, Ohio. Subsequent recoveries of a number of well-preserved examples, each similarly from the same formational member, completed our knowledge of these remarkable lower mouth parts[2]. The elements, however, have never been associated with any other bones, despite the ever diligent search exercised by all collectors of 'fossil fish bones' in the Cleveland region. The general morphology and relationships of this species have remained matters of conjecture. Much interest, therefore, attaches to a recently prepared specimen in the Cleveland Museum of Natural History which permits the addition of the following few items of structural information, and which seems to promise, as well, a slight extension in the stratigraphic range of *Diplognathus*.

The present specimen (No. 7255, C. M. N. H.) was contained in a limy, spherical concretion, collected on June 27, 1940, by the authors at a point 35 feet above the base of the black Ohio Shales, in an abandoned quarry of the Southwest Portland Cement Company, 2 miles west of East Liberty in Logan County, Ohio. The site is on the eastern flank of the so-called Bellefontaine Hills, an outlier of the Cincinnati Arch. Apparently an almost complete assemblage of bones from one individual is included. It has been necessary, however, to confine the present remarks to the right and left infero-gnathals with their corresponding antero-infero-gnathal ossifications, and the postero-supra-gnathal and suborbital plates from the left side. These are well preserved in the central core of the concretion. The remaining elements of the skeletal complex, lying more peripherally, are so badly fragmented and distorted that both their preparation and identification have been considered impossible.

[1]Ann. N. Y. Acad. Sci., Vol. I, 1878, p. 188.

[2]Newberry, Mon. U. S. Geol. Surv., XVI, 1889, pp. 159-161, pls. XI-XII.

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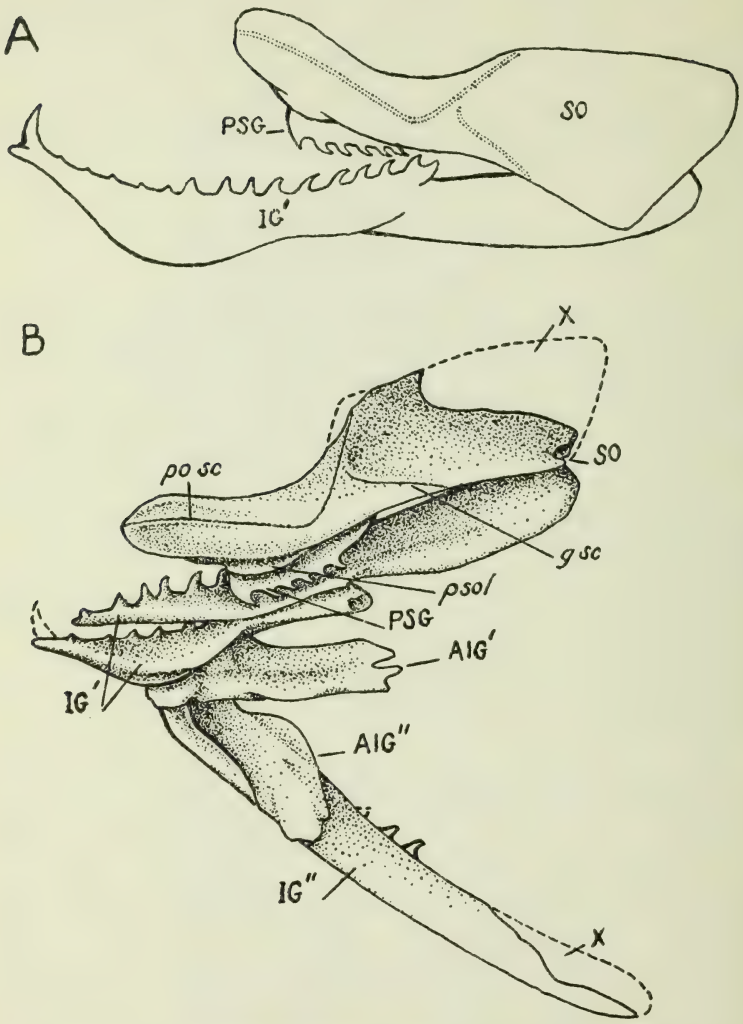

FIGURE 1.— *Diplognathus mirabilis* Newberry (No. 7255, C. M. N. H.). Attempted outline restoration in left lateral view (A); and sketch of the disassociated cheek and mouth parts (B). Reproduction approximately x ½.

AIG', left, and AIG", right, antero-infero-gnathal; gsc, gnathal sensory canal; IG', left, and IG", right, infero-gnathal; posc, post-suborbital sensory canal; PSG, postero-supra-gnathal; psol, lingual process on suborbital 'handle'; SO, suborbital; X, portions covered by matrix or unidentified bone fragments.

A grant-in-aid from the Marsh Fund permitted the collection of this specimen, among others, from exposures of the Ohio Shales outside the immediate vicinity of Cleveland during the summer of 1940, and we are happy in an opportunity again to express our gratitude to the authorities of the National Academy of Science. We wish also to acknowledge our most sincere appreciation for the generous support accorded the Cleveland Museum of Natural History by Mr. Guerdon S. Holden, which has made possible the publication of the results of this investigation.

Description.— Both the infero-gnathal plates are complete and their entire marginal outlines are displayed, although preparation exposed only the external face of the left element, and of the bone from the right side only the lateral face in its anterior third and the lingual face in its posterior two-thirds. The plates measure 18.2 cm. in total length, and possess an average depth of 2.1 cm. These dimensions portray the exceptional lowness of the bones in proportion to their lengths. Characteristically arthrodiran in construction, the posterior blade division of the bone is a vertically inclined lamina of marked longitudinal straightness and of moderately robust development. In cross-section, the lingual face of this part is nearly flat while the lateral face is boldly convex. The maximum transverse thickness is uniformly distributed along a longitudinal axis situated above the middle frontal plane. In either lateral or lingual views the margins of the blade are practically straight dorsally; symmetrically rounded posteriorly; and gently convex ventrally. The length of the posterior division, measured along the dorsal margin, represents two-fifths the total length of the element, and the proportional shortness of this member constitutes a major diagnostic feature of the typical *Diplognathus* infero-gnathal.

The anteriorly adjacent functional division of the infero-gnathal is almost one half again as long as the posterior blade part, and thus, in overall length represents three-fifths the total length of the bone. It is likewise thicker in transverse section, the degree of which is shown by the distinct offset extending from the posterior limit of the dorsal oral margin obliquely antero-ventrally across the lateral face of the plate. This anterior part, also, possesses greater depth due to the heightening of the oral margin by the development of a dorso-lateral flange. The relationships of the two divisions are further characterized by the fact that in any horizontal section the general longitudinal straightness of the blade is carried forward into the functional portion. Despite this, however, the divisions do not lie in the same vertical planes. Either one part or the other appears to have been rotated on the longitudinal axis in such a manner that the inferior margin of the functional end lies mesial,

and the superior margin lateral to the corresponding edges, respectively, of the blade.

Fully one-third the length of the functional division lies in advance of the symphysis, as defined by the area for articulation with the antero-infero-gnathal ossification. This results from the development of an attenuated anterior extremity, which, triangular in section, presents three ridges and three encompassed faces, all tapering in convergence distally. The first ridge, dorso-lateral in position, is the straight forward and slightly upward extension of the oral margin. The second is situated ventro-laterally and represents the anterior continuation of the downwardly produced ventral margin of the division externally in the symphyseal region. The third ridge is assumed to mark the median line of the mandibular rami, and arises as a transverse thickening of the ventral margin immediately

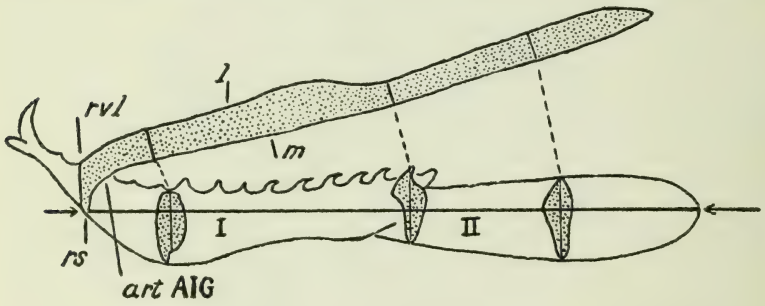

FIGURE 2.— Diagram of the left infero-gnathal of *Diplognathus mirabilis* with superimposed transverse and frontal sections (shaded), to show the contours and proportions of parts. Reproduction approximately x ½.

art AIG, articular area for antero-infero-gnathal ossification; l, external side; m, internal side; rs, mesial ridge of pre-symphyseal process; rvl, ventro-lateral ridge of pre-symphyseal process; I, functional division; II, blade division.

anterior to the antero-infero-gnathal articular surface. Concerning the faces of this anterior structure, the external surface, below the straight oral margin, is curved antero-mesially to its juncture with the ventro-lateral ridge, and is, thus, convex in both transverse and horizontal sections. The surface of the broadened ventral margin is flat and is directed antero-ventrally. The third face, lying between the oral margin and the mesial symphyseal ridge, is generally convex in section anteriorly, and somewhat concave posteriorly. It is inclined dorso-mesially and backwardly. Both the dorso-lateral flange and the symphyseal ridge are set with an apparently variable number of tooth-like protuberances. In the present specimen, those on the

oral margin number 15, of which the anterior 5 are rather small and the remainder larger, sharply conical, and postero-mesially recurved. The symphyseal row of denticles is not here exposed but is known to consist of from 4 to 6 bony projections. The first or most anterior one possesses the highest and most slenderly conical form. Posteriorly the members of this series progressively decrease in height but increase in diameter. Most, if not all of the denticles on the jaw of *Diplognathus* are hollow from their tips to the level of their bases.[3]

The antero-infero-gnathal bones appear to be composed of the same highly cancellous tissue previously remarked in the corresponding elements of *Titanichthys* and *Dinichthys*[4], and have suffered the same compression and consequent distortion during preservation encountered in all examples of these last mentioned genera. In addition, the plates have been displaced so that only the mesial surfaces can be observed. Thus, aside from a longitudinal slenderness, a generally heavier anterior portion where in contact with each other across the median line, and a feathery extinction postero-laterally as they traverse the obliquely grooved ventral margin of the infero-gnathal plates, their structural details must remain obscure.

The previously unknown postero-supra-gnathal element must be considered of a shearing type in that it is in externally overlapping opposition to the infero-gnathal. The plate is higher and thicker anteriorly than posteriorly, suggesting a well developed and inwardly projecting process from the forward part of its dorsal margin similar to that in the Coccosteids and other Arthrodires. The external face of the bone is nearly straight antero-posteriorly, but is markedly convex in transverse section. This convexity is accentuated by a longitudinal series of 6 large and conical denticles which are closely set on the ventral oral margin at right angles to the external face and recurved postero-mesially. The posterior margin commonly denticulated in *Coccosteus* and *Dinichthys terrilli* is unornamented. Of especial note is the remarkable shortness of the postero-supra-gnathal. Unless extremely altered by some undetected distortion, it opposed only the posterior third of the length of the infero-gnathal oral border.

The suborbital plate, in keeping with the slender length of the lower jaw, is proportionally long and low. The shallowly concave orbital excavation of its dorsal margin anteriorly may be arbitrarily

[3]Heintz, Acta Zoologica, Bd. XII, 1931, pp. 225-239, pls. I-II, text figs. 1-11.

[4]Dunkle and Bungart, Scient. Publ. Cleve. Mus. Nat. Hist., Vol. VIII, No. 4, May 1, 1942, pp. 49-60, text figs. 1-4.

said to divide the element into equal posterior 'blade' and antero-ventral 'handle' portions. The postero-dorsal angle of the vertically expanded 'blade' is concealed by unidentified bone fragments, and the exact outlines of the plate in this region are unknown. An approximation of profile is suggested by the projection of the exposed parts of the dorsal and posterior margins (Fig. 1, B.). This restoration, however, must be considered as questionable since the area enclosed may also include that occupied by the post-suborbital bone. The antero-ventral 'handle', with parallel concave dorsal and convex ventral margins, exhibits a very deep lateral face, which is the direct forward prolongation of the posterior 'blade'. Its anterior extremity is rounded in profile, and must not have articulated as in *Dinichthys terrilli* by interlocking with the heavy antero-ventral edge of the pre-orbital plate. Rather it would seem to have overlapped the antorbital process externally as in *Heintzichthys*. While proportionately equal if not exceeding the homologous suborbital process of *D. terrilli* in degree of transverse thickening, this structure in *Diplognathus* is not indicated to have projected as far ventrally in external abutment to the postero-supra-gnathal. Similarly occurring in *D. terrilli*, the slight emargination to be observed in the ventral margin of the posterior 'blade' portion may perhaps be attributed to the massive development of the anterior lingual process of the 'handle'.

The usual post-suborbital and gnathal sensory canals are narrowly and shallowly incised on the lateral face of the suborbital plate. The former extends, roughly paralleling the orbital margin, from the antero-dorsal corner of the 'blade' downward, and thence in a rounded but none the less sharp bend forward along the 'handle'. The latter is anteriorly not joined with the post-suborbital canal, and postero-ventrally runs off the edge of the 'blade' at approximately its middle.

Discussion.—The oral margins of the arthrodiran infero-gnathal elements seem to be zones of very active growth. In certain groups of these fishes from the Ohio Shales, the rate of growth appears to be accelerated in the symphyseal region, with the result of formidable dorsal cusps among the predaceous Coccosteids and Dinichthyids, the forwardly attenuated and denticulated process in *Diplognathus*, and the extraordinary ventro-mesial projection among the bottom-feeding Titanichthyids[5]. These modifications, however, render attempts to homologize the structural details of the anterior extremities of slight aid in the solution of any problems pertaining to the orientation of poorly understood infero-gnathal bones. Cor-

[5]Dunkle and Bungart, Scient. Publ. Cleve. Mus. Nat. Hist., Vol. VIII, No. 4, May 1, 1942, pp. 49-60, text figs. 1-4.

rect placement can be approximated only from a comparison of the basically similar grosser structures and arrangement of articulating plates. Thus, influenced by the well substantiated and generally accepted orientation of the *Dinichthys terrilli* infero-gnathals, as recently supported by Heintz[6], the present authors assume the alignment of the mesial pre-symphyseal ridge in *Diplognathus* along the median line. The thinness of the antero-infero-gnathal plates in their heavier anterior portions shows these ridges to have been closely apposed, and also permits the postulation of a relatively narrow divergence of the infero-gnathals posteriorly. This narrow width in the 'quadrate' region and the great proportional length of the lower mouth parts tend to indicate a long, slender shape of the head of *Diplognathus*. The shallowness of the suborbital suggests that these proportions were accompanied by a general lowness, as well.

Speculation on the condition of the antero-supra-gnathal element in *Diplognathus* is invited by the shortness of the posterior portion of the extensive infero-gnathal margin opposed by the postero-supra-gnathal plate. In all Ohio Shales Arthrodira with shearing type mouth parts, this upper anterior element, where known, overlaps the antero-dorsal extremity of the infero-gnathal externally, both in front and at the side. Discounting the possibility of a free projection of the lower jaws in advance of the rostral tip, since it seems improbable that the large symphyseal denticles were not functional, the attainment of a comparable arrangement in *Diplognathus* with its unique pre-symphyseal development, would necessitate a greatly enlarged antero-supra-gnathal. The fact is demonstrable, however, that in the present form, the ratio between the length of the blade division and the length of the infero-gnathal from the antero-infero-gnathal to the postero-infero-gnathal plates, is practically the same as that possessed by the older and more generalized *Coccosteus*. It would, therefore, perhaps be as logical to assume a retention of the usual size of the antero-supra-gnathal after a necessary loss of its antero-mesial flange, accompanied by a rostral development with a commensurate elongation of the median supra-gnathal, an element observed by Heintz[7] in *Coccosteus* and now identified but undescribed in all members of the *Dinichthys terrilli* group.

The first reference to the affinities of *Diplognathus* was by Newberry[8] who provisionally considered both *Glyptaspis* and *Tra-*

[6]Amer. Mus. Nat. Hist. Bashford Dean Mem. Vol., Art. IV, pp. 115-224, pls. I-IX, 91 text figs.

[7]Norsk Geol. Tidss., Bd. XII, 1931, pp. 291-314, pls. I-II, text figs. 1-12.

[8]Mon. U. S. Geol. Surv., XVI, 1889, pp. 159-161, pls. XI-XII.

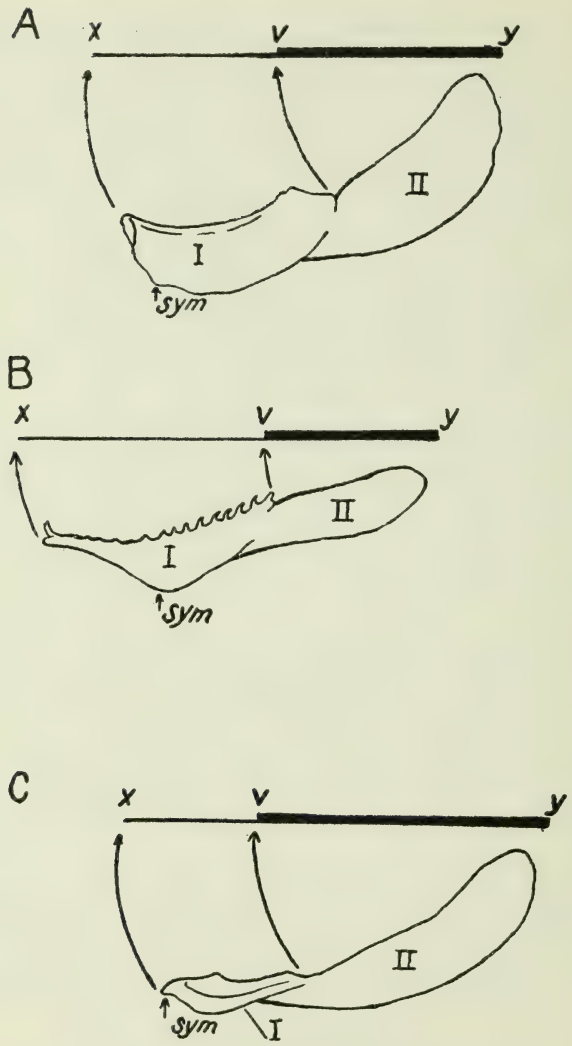

FIGURE 3.— Diagrams of the left infero-gnathal of (A) an undetermined Coccosteid, (B) *Diplognathus mirabilis*, and (C) *Mylostoma variabilis*, to show the degree of variation in the proportions of homologous parts. Reproduction a unit reduction equal to approximately x ¼ the *Diplognathus* specimen.

sym, anterior limit of the antero-infero-gnathal articulatory area; v—y, projected entire length of blade division; x—v, projected entire length of functional division; I, functional division; II, blade division.

chosteus. Later, Hussakof[9] also tentatively acknowledged the latter form as a possible relative. While in our present knowledge the lack of any known tuberculated bone ornamentation together with the peculiar development of the infero-gnathal and suborbital plates mark *Diplognathus* as generically distinct, not enough is yet known of any one of the 3 genera to prove or to disprove phylogenetic relationship.

Eastman[10] considered *Diplognathus* to be a Mylostomid, and this belief has received the widest acceptance. The broad dorso-mesial face of the pre-symphyseal process in *Diplognathus* is admittedly suggestive of the crushing type mouth parts of *Mylostoma*. However, neither the width of this infero-gnathal part need necessarily portray the condition of the supra-gnathal elements in any Arthrodire, nor is the shearing type postero-supra-gnathal in keeping with the Mylostomid condition. In added doubt of the validity of this supposed relationship, the present specimen permits an analysis of the jaw mechanism which reveals differences here considered to be of great developmental importance. In this latter regard the present authors will attempt to give their opinions immediately below.

If the gnathostomous character of arthrodiran and antiarch jaws, as presented in numerous recent papers by Gross, Heintz, Stensiö, and Watson (among others) be accepted, the antero-infero-gnathal and postero-infero-gnathal elements may perhaps be best interpreted as anterior and posterior ossifications, respectively, of the Meckelian cartilage. The infero-gnathal plates are borne dorsally astride, with their posterior ends mesial and their anterior extremities lateral to this primary mandibular complex. Of the dorsally opposing palato-quadrate cartilage, the post-suborbital bone is considered its posterior ossification; and as evidence for a connected, anteriorly adjacent cartilaginous portion there is offered the longitudinal groove on the lingual process of the suborbital 'handle'. This cartilage would have helped to support the postero-supra-gnathal from above. The postero-infero-gnathal plates articulate on the mesial side of the post-suborbital, and the infero-gnathal must have followed the ventro-lateral edge of the palato-quadrate forward. From these attempted homologies, it may be postulated that the adductor muscles, originating on the expanded edge of the marginal plate, would pass downward to their insertion on the lower jaw mesial to the suborbital and lateral or structurally dorsal to the restored palato-quadrate. The lengths of both the vertically expanded blade portion of the suborbital and the posterior blade division of the

[9]Mem. Amer. Mus. Nat. Hist., Vol. IV, Part III, 1906, p. 149.

[10]Ann. Rep. Iowa Geol. Surv., XVIII, for 1907 (1908), pp. 181, 285.

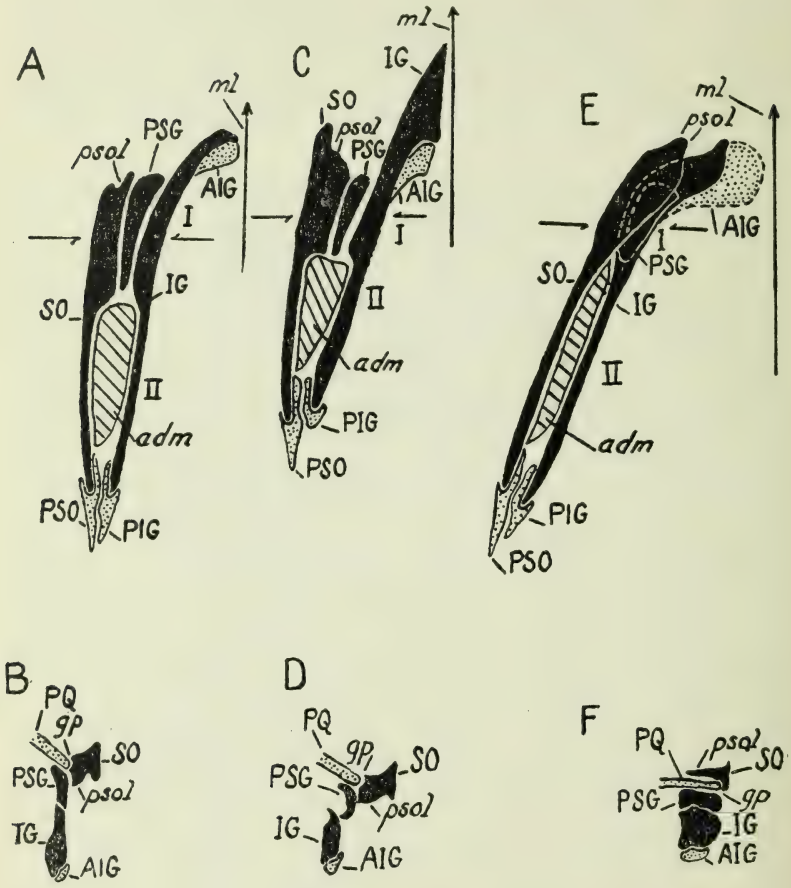

FIGURE 4.— Idealized frontal and transverse sections through the cheek and gnathal elements of (A and B, respectively) an undetermined Coccosteid, (C and D, respectively) *Diplognathus mirabilis*, and (E and F, respectively) *Mylostoma variabilis*, in gnathostomous arrangement to show the degree of variation in the proportion of homologous parts. Reproduction as in Figure 3.

adm, mandibular adductor muscles; AIG, antero-infero-gnathal; gp, groove for the palato-quadrate cartilage on the lingual suborbital process; IG, infero-gnathal; ml, median line of the head; PIG, postero-infero-gnathal; PQ, restored palato-quadrate cartilage; PSG, postero-supra-gnathal; PSO, post-suborbital; psol, lingual process of the suborbital 'handle'; SO, suborbital; I and II, functional and blade divisions, respectively, of the infero-gnathal.

infero-gnathal may then be considered indices of the length of the space occupied by the adductor muscles. Furthermore, some approximation to the cross-sectional area of this space may be approached through the correct orientation of all concerned bones in their relations to each other.

We have diagrammatically figured (Figs. 3, A; and 4, A, B) the infero-gnathal of the most generalized Coccosteid in our collections, for purposes of comparison in the application of the above considerations to the question of relationship between *Diplognathus* and *Mylostoma*. In this specimen[11], it may be noted that the blade and functional portions are of almost equal proportions. The blunt shearing edge of the oral margin is similar in degree of development to that of *Coccosteus*, and seems to be indicative of a predaceous tendency. For this reason the suborbital has been restored in the relatively robust dimensions of the last mentioned form. The adductor muscles could, therefore, have been relatively large, and a well balanced jaw the result.

In *Diplognathus* (Fig. 3, B) the development of an attenuated extremity has made the functional division much longer than the blade portion. On the physical principles of levers, a considerable loss of efficiency is thus caused. This loss (Fig. 4, C, D) appears to have been compensated for, to some extent, by the increase of the cross-sectional area of the adductor muscles through a somewhat greater production of the mesial suborbital process. However, the straightness of the infero-gnathal and lowness of the suborbital suggests muscles of very short fiber length. These interpretations favor the assumption that the jaws of *Diplognathus* were relatively weak and perhaps actually represent the grasping adaptation originally suggested for them by Newberry[12].

A similar analysis of the jaw of *Mylostoma* reveals a necessarily more complex history. A demand for a greater functional efficiency was presumably occasioned by the adaptation to a crushing 'dentition'. This was answered through a lengthening of the blade division of the infero-gnathal, which is the space over which the force of the adductor muscles was exerted (Fig. 3, C). No transverse increase in the cross-sectional area of the muscles seems to have accompanied

[11]This undetermined specimen (No. 7246, C. M. N. H.), which is perhaps to be classed with the '*Dinichthys*' *pustulosus* – *Protitanichthys* group of Arthrodires, was collected from the highly pyritic bone bed at the top of the Prout limestone, an upper middle Devonian stratum. For the description, distribution, and correlation of the Prout limestone, *cf.* Stumm, E. C., (Abstract) Ohio Journ. Sci., Vol. XLI, No. 6, 1941, p. 415; and Cooper, G. A., et al., Bull. Geol. Soc. Amer., Vol. LIII, No. 12, Part 1, 1942, pp. 1729-1794, 1 chart.

[12]Mon. U. S. Geol. Surv., XVI, 1889, pp. 156-161, pls. XI-XII.

this antero-posterior lengthening. The latter fact is inferred from the structure of the lingual process on the suborbital 'handle' (Fig. 4, E, F). While the thin suborbital shelf is as wide as in *Diplognathus*, the palato-quadrate groove is situated far laterally on its ventral surface, which must have served mainly as a strengthening abutment above the palato-quadrate and the broad, heavy, postero-supra-gnathal grinding plate. In place of heavier muscles, the pronounced curvature of the plate in a vertical plane would tend to lengthen the fibers. In summary, therefore, 3 factors, the lengthening of the infero-gnathal blade, its downward arch forwardly, and the long muscle fibers combine to increase both the arc and speed by which the functional division can act, and thus implement the effective utilization of maximum mechanical advantage. It is obvious, from the foregoing, that the present authors believe *Diplognathus* and *Mylostoma* to be possessed of totally different adaptations. Unfortunately there is no way at the present time of computing the duration of their separate development histories; and while admitting the possibility of common generalized ancestry, we can not, on the basis of their structural condition in the Ohio Shales, support any contention of close relationship.

In conclusion, the occurrence of *Diplognathus* in an apparently typical Huron Shale concretion from the basal layers of the Ohio Shales in central Ohio is of interest. In northern Ohio, the formation is divided into 3 members, and heretofore, this particular Arthrodire has been known from only the uppermost of these, the Cleveland Shale. Lacking the middle gray Chagrin Shale member, the Ohio Shales are not differentiated in the central and southern parts of the State, despite the persistence of definitive lithological characters between the lower Huron and upper Cleveland black shale members noted by Kindle[13] throughout the entire areal extent of the formation. While it is perhaps not advisable to denote the present occurrence in Logan County as Huron Shale, it may be permissible to voice our expectation of finding *Diplognathus* in the recognized Huron Shale exposures in the northern Ohio counties of Erie and Huron.

[13]Amer. Journ. Sci., Ser. 4, Vol. XXXIV, 1912, pp. 187-213.

SCIENTIFIC PUBLICATIONS

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A NEW ARTHRODIRAN FISH FROM THE UPPER DEVONIAN OHIO SHALES

BY

DAVID H. DUNKLE

AND

PETER A. BUNGART

The identifiable remains of the relatively small-sized members of the Upper Devonian fish fauna from the Ohio Shales formation have always been those most infrequently encountered in collecting. This fact does not appear to result from any particular rarity of occurrence within the fauna. Rather it seems to be attributable to the pardonable inadequacies of collectors, since the smallness and thinness of the bones, scales, and teeth almost completely preclude their detection in the tens of feet of finely-bedded, vertical cliffs; and since weathered, indeterminate fragments from small forms are not uncommonly found in the definitive 'bone-bed' horizons within the Huron and Cleveland Shale members of the formation. The most satisfactorily preserved and intelligible examples of the diminutive representatives of the assemblage have been found usually during the routine exploration of 'Big Creek' and cone-in-cone types of Cleveland Shale concretions, both of which are easily detected in the shale because of their large size, deformation of adjacent strata, and characteristic discoloration of exposed edges; and both of which, also, are classically known for containing the best specimens of the shark *Cladoselache*. The number of recoveries in this manner, however, has been unfortunately small and with little duplication of specimens. Consequently, our knowledge of these fishes is admittedly incomplete. Therefore, any additional structural information concerning previously described genera and species, and the recognition of new forms is of especial interest.

The present paper calls preliminary attention to a diminutive arthrodire which exhibits a combination of structural modifications marking it as a unique addition to the Cleveland Shale fauna. The description is based mainly on 3 specimens in the paleontological collections of the Cleveland Museum of Natural History. Each is

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contained in one of the ellipsoidal concretions typical of the exposures of the Cleveland Shale in the Big Creek (Cuyahoga County, Ohio) section. While no one is entirely complete, these specimens supplement each other in nearly all important details and thus permit a fairly comprehensive diagnosis.

Our sincere thanks are extended to Dr. William K. Gregory for his generous permission to draw freely from the magnificent collection of fossil fishes in the American Museum of Natural History for comparative materials and to Dr. J. Le Roy Kay for granting certain study facilities at the Carnegie Museum. We also gratefully acknowledge the special fund provided by Mr. Guerdon S. Holden of Cleveland for the publication of these notes.

Paramylostoma[1], gen. nov.

Diagnosis.—A small euarthrodiran fish which may be distinguished from all Cleveland Shale members of the same suborder in the possession of the following combination of structural features. Known mouth parts directly apposed and thickened in a crushing or grinding adaptation, but with the postero-supra-gnathal retaining a distinct, mesially directed process from the anterior half of its dorsal margin, and the antero-infero-gnathal very thin. Cranial shield very probably fenestrated dorso-medially between the centrals and behind the pineal plate; marginals high and articulating with the centrals antero-mesially; and the much enlarged orbit surrounded by the pre-orbital, postorbital, and suborbital plates alone. Medio-dorsal quadrangular, slightly wider than long, with well developed keel, and with little if any emargination of its anterior edge. Antero-lateral triangular; its antero-ventral angle much produced, tapering directly in profile without a marked bend and with a wide internal shelf on which the intero-lateral articulates ventrally. Antero-ventro-lateral and postero-ventro-lateral elements of approximately equal length, and narrow. Antero-medio-ventral proportionately short and narrow without antero-lateral processes. Postero-medio-ventral two-thirds the length of the antero-ventro-lateral, and distinctly diamond-shaped, the greatest width equalling one-half the length of the plate.

Genotype.—*Paramylostoma arcualis,* sp. nov.

Paramylostoma arcualis, sp. nov.

Diagnosis.—The same as for the genus (the only species).

Holotype.—No. 5284, Cleveland Mus. Nat. Hist.: a laterally crushed but practically complete assemblage of bones from 1 individual mounted as contained in a typical 'Big Creek' concretion; from the Cleveland Shale member, Ohio Shales formation of the

[1] *Para,* near, beside; +*Mylostoma.*

Upper Devonian on the Northwest Branch of Big Creek (Berea Quadrangle), Cuyahoga County, Ohio; collected, May 5, 1925, by Peter A. Bungart.

Description.—The exactness of the accompanying reconstructed drawings (Fig. 3) is limited by 2 factors. First, in disassociated plates even where the entire marginal outlines are observable the bony tissue is of such exceptional thinness that the areas of overlap by adjacent elements are with but few exceptions poorly indicated. Second, in articulated complexes of plates such as the cranial shield where the full outlines of the separate elements are not visible, it has been necessary to determine the position of poorly defined sutures through evidences presented by the very prominent radiating lines of ossification. The illustrations, however, are considered by the present writers to show the general relationships of parts and their distinctive features in such close approximation to their original condition that more than the following brief characterization is unnecessary.

Cranial shield short and with a high transverse dorsal arch; emargination by the very large orbits which occupy the entire anterior half of the lateral margins giving the roofing armor an appearance of extreme proportional narrowness across the snout and of shortness to the median portion lying behind the transverse plane of the post-orbital processes; shield much extended postero-laterally and postero-ventro-laterally; and the deep notch of the unarmored nuchal space forming a 90 degree angle in the posterior border of the nuchal[2] (medio-basal) plate at the median line. In proportions, the maximum posterior width of the shield, measured over the externo-dorsal curvature, twice the approximately equal dimensions of width across the pre-orbital processes and the median length, and one-half greater than the maximum observable length between the anterior extremity of the pre-orbital and posterior margin of the paranuchal[2] (externo-basal) plates.

Nuchal plate exhibiting little apparent ventral thickening across its posterior edge; almost twice as wide as long[3]; bluntly truncated anteriorly; and extended in widely divergent arms, which postero-laterally bound the deep median nuchal notch. Paranuchals triangular in shape and roughly as long as high in over-all measurements;

[2]Following the current usage of Gross and others, the present writers will employ, hence-forth, the terms nuchal and paranuchal in place of respectively, medio-basal and externo-basal. Avoidance of the term basal for elements of the dorsally roofing cranial shield seems desirable because of the presence in *Coccosteus* (Hills, Geol. Mag., Vol. LXXIII, 1936, pp. 213-226, 6 figs. 1 pl.), also *Leiosteus and Pholidosteus* (Stensiö, K. Svenska Vetensk. Handl., Vol. XIII, 1934, pp. 1-79, 30 figs., 14 pls.), as well as in at least 2 genera of euarthrodirans from the Ohio Shales of plates intimately associated with the ventral chondrocranial basis. These latter elements are undoubtedly to be homologized, in part, with the ventral basal elements of acanthodians (Watson, Philos. Trans. Roy. Soc. London, Ser. B, Vol. CCXXVIII, 1937, pp. 49-146, 25 figs., 10 pls.).

[3]Measured over the greater external curvature.

the condylar fossae, with their dorsal lips more produced than the ventral ones, broad, deep, but longitudinally shallow; and the glenoid processes short but robust. Centrals irregularly ovate; their maximum widths three-fourths their greatest lengths; in contact with each other only posteriorly for one-third their total median length; anteriorly the mesial edges diverge laterally, permitting the very probable postulation of a fenestration of the roof behind the pineal plate. Pineal and rostral elements unknown. Pre-orbitals longer than wide and exhibiting a proportionately greater thickening of their antero-ventral margins into pre-orbital processes than possessed by the highly predaceous *Dinichthys terrelli*. Postorbitals as long as the pre-orbitals but much narrower; postorbital processes developed ventrally at the postero-lateral angles of these plates just in advance of the transverse postorbital-marginal suture. Marginals large, possessing heights approximately twice their lengths; and in contact with the centrals antero-mesially. Postmarginals small, and higher than long.

Suborbitals long in proportion to their heights; posterior 'blade' portions low, triangular, and with vertical laminae representing one-half the total lengths of the elements; anterior 'handle' parts below the orbit low but bearing a broad shelf-like process mesially. Post-suborbital triangular and about one-half the size of the suborbital 'blade'.

Medio-gnathal, and antero-supra-gnathals unknown. Oral margins of the postero-supra-gnathals and infero-gnathals directly apposed and thickened in a grinding or crushing adaptation. Postero-supra-gnathals showing a long, low, but none the less distinct process directed mesially from the anterior one-half of their dorsal margins; and having lengths more than three-fourths that of the anterior functional division of the infero-gnathal. Infero-gnathals arched ventrally along their longitudinal axes; posterior blade divisions slightly less than two-thirds the total lengths of the elements, thin and of maximum vertical expansion posteriorly; anterior functional portions with oral margins much produced dorsally and more transversely broadened anteriorly than posteriorly. Antero-infero-gnathals small and of slight thickness, showing that the infero-gnathals closely approach each other at the mandibular symphysis.

Dorsal body armor high, moderately narrow, and very short. Medio-dorsal quadrangular, and a little wider than long; anterior margin straight or with a very slight emargination; the well-developed ventral keel extending from the antero-median edge of the plate backward to a robust dorsally grooved extremity which projects far beyond the posterior margin of the dorsal plate. Antero-dorso-laterals twice as high as long; anterior edges greatly thickened both above and below the strong horizontal condyles; and showing a

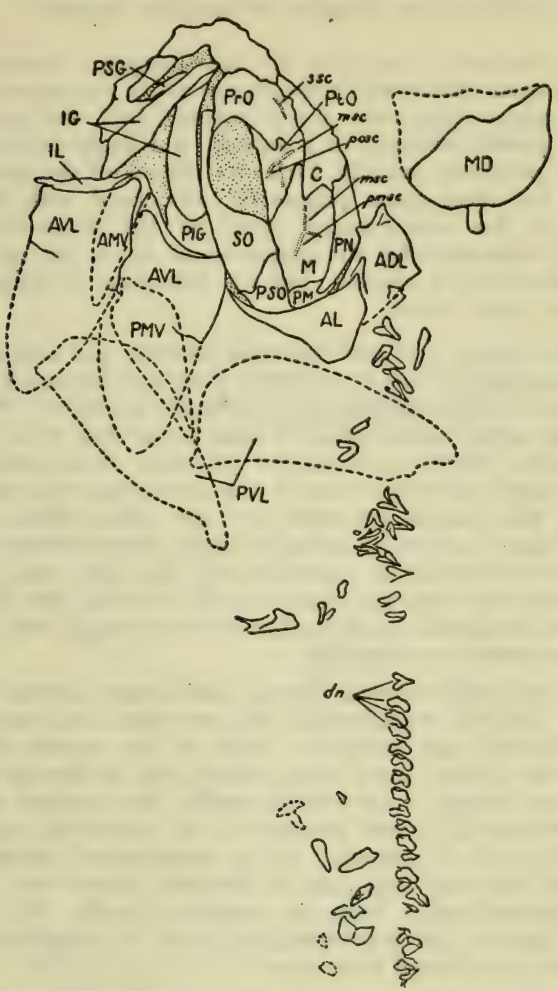

FIGURE 1.—*Paramylostoma arcualis* Dunkle and Bungart (No. 5284, C. M. N. H.). Sketch of the holotype as prepared with dashed lines indicating either the outlines of bones contained at deeper levels within the matrix or the impressions of bones. Reproduction approximately x ¼.

Explanation of Symbols.—ADL, antero-dorso-lateral; AL, antero-lateral; AMV, antero-medio-ventral; AVL, antero-ventro-lateral; C, central; dn, axial neural supports; IG, infero-gnathal; IL, intero-lateral; M, marginal; MD, medio-dorsal; msc, marginal sensory canal; PIG, post-infero-gnathal; PM, postmarginal; pmsc, postmarginal sensory canal; PMV, postero-medio-ventral; PN, paranuchal; posc, sub-post-orbital sensory canal; PrO, pre-orbital; PSG, postero-supra-gnathal; PSO, postsuborbital; PtO, postorbital; PVL, postero-ventro-lateral; SO, suborbital; and ssc, pre-orbital sensory canal.

peculiar excavated concavity in the margins, postero-ventrally. Antero-laterals distinctively triangular in shape; the antero-dorsal and postero-ventral edges both gently concave; and the antero-ventral angle in profile produced in a straight and finely tapering process which is broadened mesially. Structural details of the intero-laterals obscure, but these plates presumably articulated with the ventral surface of the antero-ventral shelf on the antero-lateral plate. Evidence observable for the possession of an as yet unrecognized postero-dorso-lateral element, but no indication of either postero-lateral or spinal plates.

Ventral armor long and relatively narrow; not attached to the dorsal body armor; and its extremity lying far forward beneath the head. Antero-medio-ventral, with its length contained 2⅔ times in that of the antero-ventro-lateral, 3 times longer than wide; and tapering forward without antero-lateral processes. Postero-medio-ventral with a length two-thirds that of the antero-ventro-lateral, proportionately the largest possessed by any Ohio Shale arthrodire, diamond-shaped and twice as long as wide. Antero-ventro-lateral and postero-ventro-laterals of approximately the same size, 2½ times longer than wide; and the length of each exceeding that of the head. Antero-ventro-laterals much produced antero-mesially and with weak spinal processes antero-laterally.

Bones all unornamented. Lateral line sensory system somewhat reduced. On the cranial shield the pre-orbital and sub-postorbital canals extended just within the edges of the centrals and not to the centers of these latter bones; lower arms of the sub-postorbital canals bent sharply backward to parallel the marginal canal, and not traversing the lateral margins of the postorbital plates; post-marginal canals not extended on the postmarginal plates; and the paranuchal (externo-basal canal of Heintz[4]) limited to a short projection antero-dorsally from the condylar fossae. No observable traces of sensory canals preserved on either the suborbital bones or the plates of the dorsal body armor.

The series of specimens here referred to *Paramylostoma* exhibits evidences of several additional ossifications not included in the characterization above given, because an incompleteness of preservation has made their interpretation difficult. In the holotype there occurs a paper-thin sheet of highly cancellous tissue lying posteriorly, mesial to the suborbital and within the cranial shield. While undoubtedly to be identified as a perichondral ossification of either the dorsal palato-quadrate portion of the first visceral arch or the wall of the braincase, the only partial exposure of this plate makes a definite determination impossible at this time. In the type specimen

[4]Amer. Mus. Nat. Hist. Bashford Dean Mem. Vol., Art. IV, 1932, p. 123.

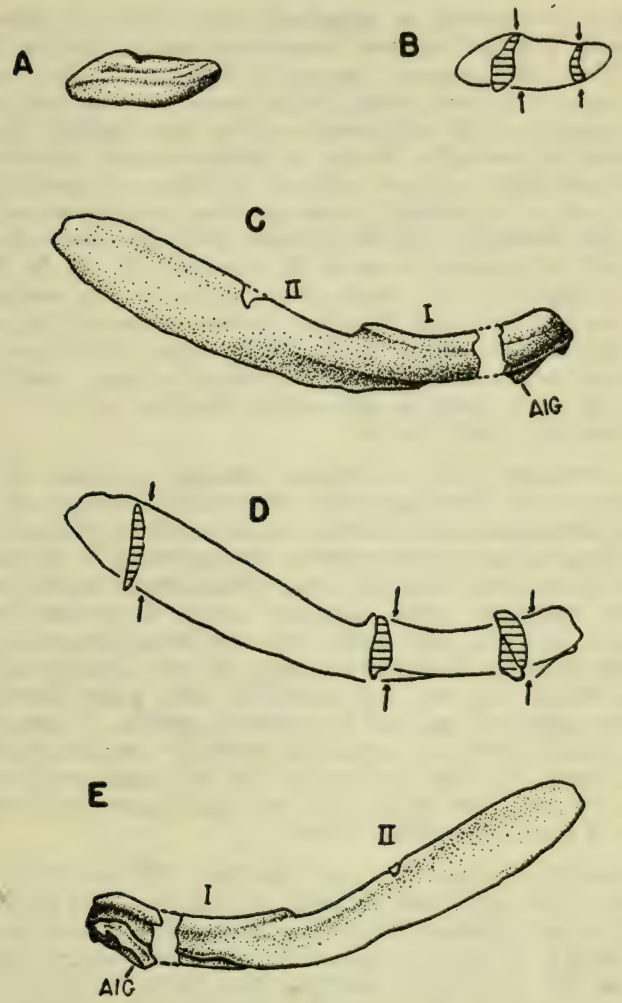

FIGURE 2.—*Paramylostoma arcualis* Dunkle and Bungart (No. 6054, C. M. N. H.). Left postero-supra-gnathal in (A) external view and (B) outline with superimposed (hachured) transverse sections; and right infero-gnathal in (C) external view, (D) outline with superimposed (hachured) transverse sections, and (E) lingual view. Reproduction slightly more than x ½.

Explanation of Symbols. — AIG, antero-infero-gnathal; and I and II, functional and blade divisions, respectively, of the element.

also there is preserved an apparently single series of paired and segmentally arranged elements immediately behind the dorsal body armor. These are composed, comparably with that of the previously noted plate, of a thin, poorly ossified tissue and are here termed neural supports of the axial structures since their laterally divergent extremities are ventrally directed in relation to the orientation of the well articulated pectoral carapace. No traces of ventral haemal supports are to be observed in the preserved trunk portion of the body. The homologue of the element called the sub-medio-dorsal by Heintz[5] is preserved in one of the paratypes (C. M. N. H. No. 6054), crushed into the postero-dorsal groove on the ventral keel of the medio-dorsal plate. Finally, a portion of one of the pectoral fins is exhibited (C. M. N. H. No. 7556) pulled slightly away from its normal position. This fragment consists of a large, unarticulated basal plate with which at right angles there are attached 5 short broad proximal radial elements.

Measurements.—The 3 Cleveland Museum specimens of *Paramylostoma* are of about equal size. Approximate averages of certain of their dimensions are as follows: cranial shield in greatest over-all length from the anterior extremity of the pre-orbital to the posterior margin of the paranuchal, 13.3 cm., median dorsal length, 9.4 cm., posterior maximum width measured across the greater external curvature, 22.0 cm., and width over the dorsal curvature at the transverse plane of pre-orbital processes, 9.5 cm.; medio-dorsal plate, greatest length, 7.3 cm., and width, 8.9 cm.; antero-dorso-lateral, maximum depth, 8.7 cm., and length at the condyle, 3.2 cm.; antero-ventro-lateral, length, 14.5 cm., and width, 5.5 cm.; postero-ventro-lateral, length, 14.0 cm., and width, 5.8 cm.; antero-medio-ventral, length, 6.5 cm., and width, 2.2 cm.; and postero-medio-ventral, length, 12.5 cm., and width, 6.8 cm.

Referred Specimens.—The type; also Nos. 6054 and 7556, Cleveland Mus. Nat. Hist., both consisting of complete head shields with incomplete and disassociated mouth parts and bones from the dorsal and ventral body armor contained in 'Big Creek' concretions; both from the Cleveland Shale member, Ohio Shales formation of the Upper Devonian on the Northwest Branch of Big Creek (Berea Quadrangle), Cuyahoga County, Ohio; collected, respectively, June 30, 1931, by Peter A. Bungart, and May 24, 1943, by Peter A. Bungart and David H. Dunkle; and also No. 7482, Amer. Mus. Nat. Hist., consisting of one-half a 'Big Creek' concretion containing disassociated plates of the dorsal and ventral armor, this from the Cleveland Shale member, Ohio Shales formation of the Upper

[5]Norsk Geol. Tidssk., Vol. XVIII, 1938, p. 15.

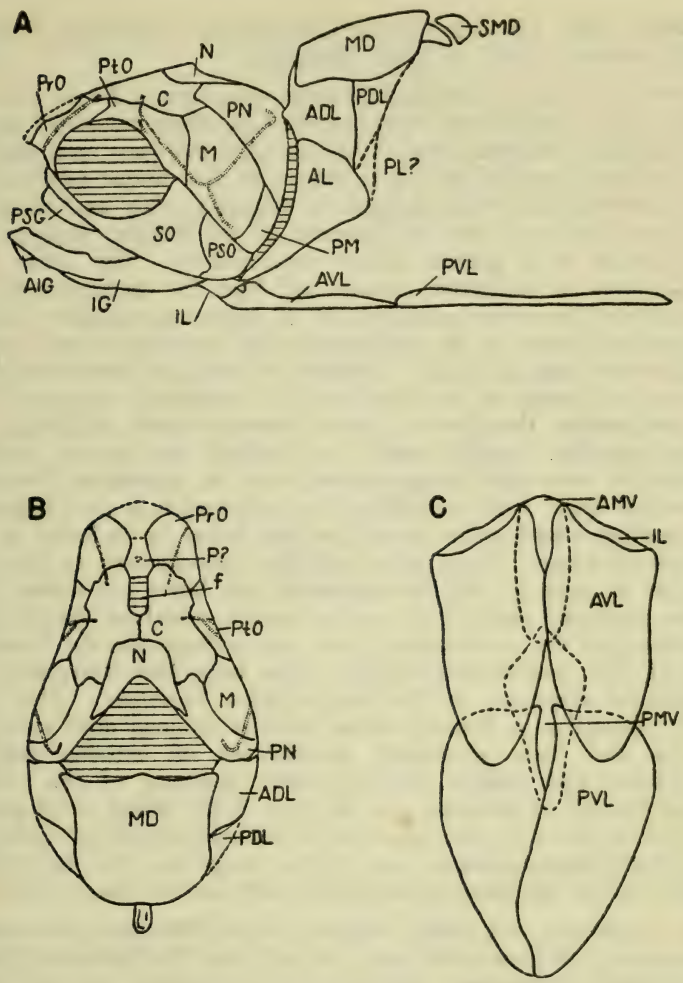

FIGURE 3.—*Paramylostoma arcualis* Dunkle and Bungart. Attempted restorations of the head and body armor in (A) lateral, (B) dorsal, and (C) ventral views. Reproduction approximately x ¼.

Explanation of Symbols.—ADL, antero-dorso-lateral; AIG, antero-infero-gnathal; AL, antero-lateral; AMV, antero-medio-ventral; AVL, antero-ventro-lateral; C, central; f, median dorsal fenestra; IG, infero-gnathal; IL, intero-lateral; M, marginal; MD, medio-dorsal; N, nuchal; P?, pineal; PDL, postero-dorso-lateral; PL?, postero-lateral; PM, postmarginal; PMV, postero-medio-ventral; PN, paranuchal; PrO, pre-orbital; PSG, postero-supra-gnathal; PSO, postsuborbital; PtO, postorbital; PVL, postero-ventro-lateral; SMD, sub-medio-dorsal; and SO, suborbital.

Devonian near Linndale (Berea Quadrangle), Cuyahoga County, Ohio; collected, 1905, by Louis Hussakof[6].

Remarks.—The 3 Cleveland Museum specimens of *Paramylostoma* will in the future be more fully described and their few minor points of individual variation noted. Systematically, this new form may be conclusively identified by the possession of the unique combination of characters set forth in the generic diagnosis. Any analysis of its structure, however, for the purpose of establishing phylogenetic relationships is at present highly unsatisfactory. This latter fact results from the collective paucity and from the incompleteness of preparation, by current standards, of the preserved examples of such arthrodiran groups as the mylostomids and selenosteids with which comparisons must be made. Members of both the above-mentioned groups are known to be distributed in distinctively separate lines of development throughout Upper Devonian times. Although yet undemonstrable, careful study has inclined the present writers toward the view that *Paramylostoma* from the uppermost Devonian Cleveland Shale, while paralleling the mylostomids in the adaptation of crushing mouth parts, should perhaps better be included in the selenosteid group. Such mylostomid-like resemblances as the proportion of parts of the infero-gnathals, the heavy pre-orbital processes, the broad mesial shelf on the anterior suborbital 'handle', the shortening of the medio-dorsal plate, and perhaps also the broadening of the postero-medio-ventral bone seem best interpreted as mechanical responses to the crushing-type 'dentition'. That this latter adaptation in *Paramylostoma* was not attained until after the typical and basic selenosteid modification of extreme anterior narrowness and median antero-posterior shortness of the cranial shield through involvement by the very large orbital development appears indicated by the retention of the dorso-mesial processes on the postero-supra-gnathals and of the deep keel on the medio-dorsal, and by the proportionately long and narrow ventral armor.

In conclusion, the closely related North American *Selenosteus, Stenosteus,* and *Gymnotrachelus,* coupled with the European genera *Pachyosteus, Enseosteus, Rhinosteus,* and *Leiosteus,* are sometimes recognized as composing a family Selenosteidae. One of the chief characteristics of this family[7], apparently based on the interpretation of the Wildungen genera alone, is the incorporation of the marginal plate in the ring of cranial shield and cheek bones that surrounds the orbit; bringing to 4 the number of elements in that series, and

[6]Although never examined by the present writers, it seems probable that the ventral armor and axial supports figured by Dean (Trans. New York Acad. Sci., Vol. XV, 1896, pp. 157-163, 2 pls.), and the infero-gnathal plates in the American Museum of Natural History and the British Museum (Natural History) identified as from immature speciments of *Mylostoma* by Hussakof (Geol. Mag., Vol. V, 1911, p. 126) may pertain to *Paramylostoma.*

[7]Gross, Geol. Palaeont. Abhandl., N. F., Bd. XIX, Heft 1, 1932, p. 16.

indicating that the postorbital processes are situated on the marginal plates. From the material in the Cleveland Museum it is possible to show that the suborbital articulates with the postorbital, not with the marginal plate, in *Stenosteus* and *Gymnotrachelus* as well as in *Paramylostoma*. This indicates that the orbital development, while relatively very great, has not proceeded as far in the North American genera as in those from Europe. Even if, therefore, the validity of the unity of the grouping is not questioned, the accuracy of the current family definition is suspect.

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PRELIMINARY NOTICE OF A REMARKABLE ARTHRODIRAN GNATHAL PLATE

BY

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AND

PETER A. BUNGART

A new species name is here proposed for a single arthrodiran gnathal element of peculiar characteristics, contained in the paleontological collections of the Cleveland Museum of Natural History. The plate exhibits perfect bilateral symmetry and an extensive oral grinding surface. Thus it is to be identified as a much enlarged upper medio-gnathal bone. This prompts its provisional reference to the genus *Dinognathus* Hussakof[1], the type species of which is similarly founded on an unassociated and homologous element from an arthrodire of as yet unknown affinities.

The present specimen was found in one of the dense, ellipsoidal concretions typical of the exposures of the Cleveland Shale in the Big Creek (Cuyahoga County, Ohio) section. In preparation the bone was completely removed from the matrix. As is common with most similarly preserved specimens, it had suffered some fragmentation and distortion apparently during the growth of the concretion, and small portions of the thinner margins of the element were not recoverable. Fortunately, however, the missing edges from one side are, for the most part, extant on the opposite one.

The present writers again are happy to express grateful appreciation to Mr. Guerdon S. Holden of Cleveland for his generous interest in their studies.

[1]Bull. Amer. Mus. Nat. Hist., Vol. XXVI, Art. 20, May 15, 1909, pp. 268-270, fig. 5.

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Dinognathus eurhinus, sp. nov.

Diagnosis.—Medio-gnathal element large, distinguished from that of *Dinognathus ferox* by reason of possessing greater width than length; superior surface articulating with the ethmoidal portion of the chondrocranium, deeply excavated on either side of a high longitudinal, dorso-median ridge, and behind an equally high anterior transverse crest; postero-lateral processes weaker, bounding a narrower and more shallowly incised postero-median notch.

Holotype.—No. 5063, Cleveland Mus. Nat. Hist.: a medio-gnathal element lacking only small fragments from parts of its margins; from the Cleveland Shale member, Ohio Shales formation of the Upper Devonian, on the Northwest Branch of Big Creek at West 130th Street (Berea Quadrangle), Cleveland, Cuyahoga County, Ohio; collected, May 15, 1923, by Peter A. Bungart.

Description.—The outlines of the plate and the proportions of its parts as reproduced in the accompanying illustrations (Figure 1) are closely accurate. With direct comparisons facilitated by the sketches of the corresponding bone from *Dinognathus ferox* (Figure 2), any detailed descriptions, for the purposes of this preliminary notice, are considered unnecessary to establish the marked differences listed in the above-given diagnosis between the genotype and the new species *Dinognathus eurhinus*.

Measurements.—The type specimen of *Dinognathus eurhinus* possesses the following measurements: maximum length, 7.8 cm.; greatest width, 10.0 cm.; greatest depth from the highest point on the antero-dorsal transverse crest to the tip of the ventral antero-median boss, 4.35 cm.; average depth of the median longitudinal thickening, 2.3 cm.; average thickness of the plate through the lateral dorsally and ventrally concave areas, 0.5 cm.; inside width between the extremities of the postero-lateral processes, 1.4 cm.; frontal depth of the postero-median notch, 1.0 cm.

The same measurements of the figured specimen of *Dinognathus ferox* (No. 6094, C. M. N. H.) are, respectively: 9.6 cm.; 7.9; 3.7; 2.0; 1.5; 4.15; and 2.1.

Remarks.—Slight reasonable doubt remains in the identification of the *Dinognathus* type of gnathal plates as anterior median elements of the upper 'jaw'. It will perhaps be remembered that in the original description[2] Hussakof oriented the bone with its postero-lateral processes directly orally, but was unable to determine whether the element was a compound 'premaxillary' or a 'premandibular' plate. Eastman[3] corrected this orientation and assigned the

[2]Bull. Amer. Mus. Nat. Hist., Vol. XXVI, Art. 20, May 15, 1909, pp. 268-270, fig. 5.
[3]Bull. Mus. Comp. Zoöl., Vol. LII, No. 14, 1909, pp. 261-270, figs. 1-3.

bone to an upper median position. In so doing, however, he advocated the theory of its derivation from the fusion of the anterior pair of mylostomid 'palato-pterygoid' plates. From the presence in *Dinomylostoma beecheri*[4] of a pair of so-called 'vomerine' elements he also predicted the occurrence of a pair of bones in advance of the medio-gnathal of *Dinognathus*. This interpretation now seems to necessitate undue contortions in homologizing arthrodiran elements between the many and widely differing forms. Heintz[5] has noted the presence in *Coccosteus* of a superior medio-gnathal bone. Comparable elements often associated with complete skeletal assemblages are well known in a number of Ohio Shales genera, although undescribed. In common with those of *Dinognathus* all bear superior surfaces variously marked for articulation with the ethmoidal portion of the cartilaginous chondrocranium, and inferior oral surfaces with median longitudinal ridges apposed to the unfused line of the infero-gnathal symphysis, bounded by lateral basined areas of varying degrees of width and concavity which are directly subject to wear by the more or less trenchant anterior tips of the infero-gnathal plates. The normal complement of upper gnathal bones in a number of arthrodires is thus 5: one antero-median symmetrical element, and 2 pairs of asymmetrical ones situated postero-laterally. The present writers are inclined to believe that this constitutes the generalized pattern for all arthrodiran fishes. Quite apart from the main theme of this discussion, this view also permits us to suggest that should an extra pair of elements actually prove to exist in *Dinomylostoma,* in addition to the paired antero-supra-gnathal, postero-supra-gnathal, and infero-gnathal plates, they will be found as orally functional antero-infero-gnathal elements.

While mouth parts undoubtedly exhibit those characteristics most expressive of arthrodiran variation, single, unassociated gnathal plates are definable only with the utmost difficulty. *Dinognathus* as well as the majority of all so-called 'mylostomids' are based on such isolated bones. The present writers have shown that a crushing dentition is not confined alone to the family Mylostomidae but is possessed in parallel tendency by the Cleveland Shale selenosteids

[4]Eastman, Bull. Mus. Comp. Zoöl., Vol. L, No. 1, 1906, pp. 23-29, pl. I, figs. 4-5, pl. II, figs. 13-16, pls. IV-V, text figs. F, G, H.

[5]Norsk Geol. Tidssk., Bd. XII, 1931, p. 296, fig. 6.

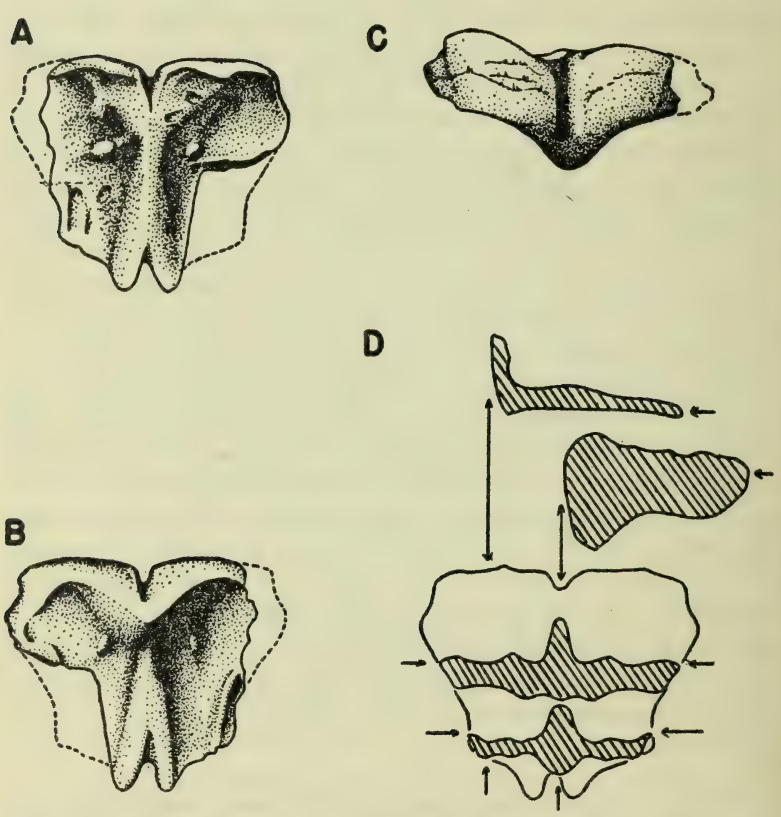

FIGURE 1.—*Dinognathus eurhinus* Dunkle and Bungart (No. 5063, C. M. N. H.). The holotype in (A) dorsal view, (B) ventral view, (C) anterior view, and (D) outline with diagrammatic transverse and longitudinal sections (hachured). Reproduction slightly more than x⅓.

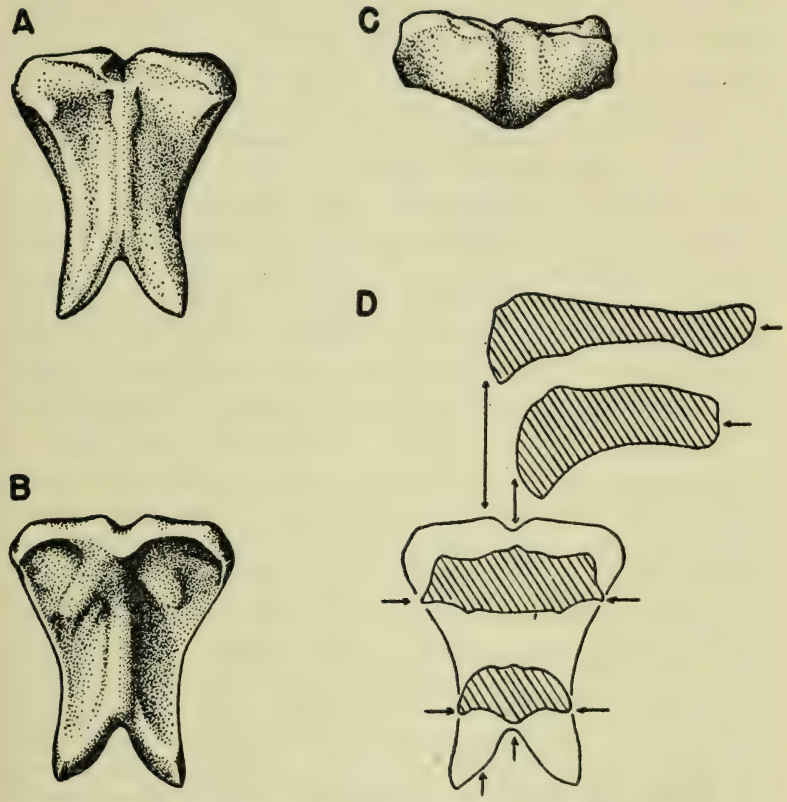

FIGURE 2.—*Dinognathus ferox* Hussakof (No. 6094, C. M. N. H.). Medio-gnathal plate in (A) dorsal view, (B) ventral view, (C) anterior view, and (D) outline with diagrammatic transverse and longitudinal sections (hachured). Reproduction slightly more than x⅓.

Gymnotrachelus and *Paramylostoma*[6]. Among the forms that must still be considered as members of the family Mylostomidae are those with apparently well-developed antero-supra-gnathal and postero-supra-gnathal plates, as characterized by *Mylostoma variabilis* and *Dinomylostoma,* and those with much enlarged medio-gnathal plates such as *Dinognathus.* This tentative grouping is indicated, despite the absence of complete 'dentitions' in any of the 'mylostomids,' by an undescribed specimen in the Cleveland Museum in which the enlargement of the medio-gnathal has proceeded at the expense in size of the postero-laterally adjacent antero-supra-gnathal, and in which the enlarged medio-gnathal is not associated with either a crushing type of postero-supra-gnathal or infero-gnathal element. These considerations may not, of course, be borne out by future recovery of complete specimens. They do, however, explain our current hesitancy in supporting Eastman's[7] unfounded association of the *Mylostoma terrelli* infero-gnathal type with the *Dinognathus ferox* medio-gnathal, and in addition they stress the uncertainty of our reference of the species *eurhinus* to the genus *Dinognathus.*

In conclusion, it is of considerable interest to postulate the occurrence of either the genus *Dinognathus* or an immediately related arthrodiran fish in the Upper Devonian rocks of northeastern Missouri. While positive osteological and systematic determinations must await some future re-examination of the specimen, the element described and figured by Branson[8] as the 'occipital' (medio-nuchal) plate of *Dinichthys rowleyi* seems more appropriately identified as an enlarged *Dinognathus*-like medio-gnathal plate. Verification of this observation will necessarily give rise to a taxonomic complication, since the so-called 'occipital' was only one of several disassociated and fragmentary bones upon which the original description of *Dinichthys rowleyi* was based without the specific denotation of a type specimen. To avoid future difficulty, therefore, and in keeping with currently accepted practices, these writers suggest that of the original material, the antero-supra-gnathal element, as perhaps the most diagnostic dinichthyid bone included, be restrictively designated the type of *Dinichthys rowleyi.*

[6]Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 2, 1939, pp. 13-28, pl. III, figs. 1-6; and Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 8, Dec., 1945, pp. 85-95, figs. 1-3.

[7]Bull. Mus. Comp. Zoöl., Vol. LII, No. 14, 1909, p. 266.

[8]Univ. Mo. Bull., Vol. XV, No. 31, Sci. Ser., Vol. II, No. 4, 1914, pp. 60-61, pl. I, fig. 1.

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SCIENTIFIC PUBLICATIONS
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A NEW GENUS AND SPECIES OF ARTHRODIRAN FISH FROM THE UPPER DEVONIAN CLEVELAND SHALE[1]

BY
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United States National Museum

During the summer of 1936, Peter A. Bungart collected an interesting concretionary fragment from exposures of the Cleveland Shale on Rocky River in Cuyahoga County, Ohio. This matrix contained a number of dorsal and ventral body-armoring plates from a medium-sized arthrodiran fish. The bones exhibit several distinctive features including a very feebly keeled medio-dorsal element; relatively short, broad antero-ventro-laterals; long, narrow postero-ventro-laterals; and a proportionately somewhat enlarged postero-medio-ventral. Although detailed comparisons have never been possible because of sketchy materials, this structural combination agrees substantially with Dean's description of *Mylostoma variabilis* Newberry[2]. In the absence of more diagnostic elements, the Bungart specimen was tentatively referred to the same genus.

During the 1943 collecting season, however, the present writer was fortunate in locating an almost complete specimen, which, while practically twice as large, without any doubt pertains to the same form. Its recent preparation has revealed not a *Mylostoma* but a previously unknown and curiously adapted arthrodire.

The discovery of the concretion containing the latter specimen followed the observation and routine sounding of an ovate bulge in the shale of the bed of Rocky River. When the surmounting shale was removed, from 8 to 10 inches of murky water flowed over the site. The lifting of the concretion, which averaged 8 feet in diameter, was accomplished almost entirely by the sense of touch. Although aided by vertical fractures, permitting removal in blocks of easily maneuverable size, a tendency of the structure to cleave horizontally in the plane of the specimen, added to the difficulty of recovery. Parts of the same elements adhered to both the upper and lower halves of the concretionary matrix, and in the lines of breakage small fragments, unknowingly, were lost in the water.

[1]Published by permission of the Secretary of the Smithsonian Institution.
[2]Mem. New York Acad. Sci., Vol. II, 1901, pp. 101-109, pls. VII-VIII, figs. 1-8.

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In preparation, with the exception of such diagnostic elements as the mouth parts, and the suborbital, antero-dorso-lateral, and medio-dorsal plates, no effort was made completely to extricate from the matrix those bones embedded in the upper half of the concretion. Only the exposed surfaces of these were cleaned. The blocks from the lower half of the concretion, however, were weathered out-of-doors throughout the winter. This procedure permitted the contained fragments of bone to be lifted free and returned to their respective positions on the upper half. The parts of the latter were then reassembled with plaster joints, and the whole, because of its wide expanse and considerable weight, was finally embedded in a re-inforced concrete slab. The completed mount exhibits a cranial shield in dorsal aspect with the right cheek plates and mouth parts crushed obliquely to the corresponding side of the shield in remarkably intact association. The complex of dorsal and ventral body armor is incomplete. Its preserved elements are disassociated and are variously exposed from either the internal or external sides.

In here describing and naming this new fish, the writer proposes honoring its discoverer and his colleague in the Department of Geology and Paleontology at the Cleveland Museum of Natural History, Peter A. Bungart, whose collecting and whose preparation work (spanning more than 50 years) constitute such an important contribution toward the advancement of knowledge of the fish fauna of the Upper Devonian Ohio Shales.

Bungartius, gen. nov.

Diagnosis.—A medium-sized euarthrodiran fish differing structurally from all other Ohio Shales placoderms whose infero-gnathal plates are non-cuspidate, by reason of the following characteristics. Cranial shield approximately as long as wide in over-all measurements, with considerable preorbital extension, and with extended but shallow postero-lateral wings. Head in restored configurations thus relatively long, low, and narrow. Orbits of moderate size and situated laterally to occupy the middle third of the marginal length of the shield. Marginal plate reduced in exceptional degree and restricted to a remote postero-lateral position. Medio-gnathal enlarged, with short anterior functional portion and a pair of slender, elongate postero-lateral processes bounding a deep, narrow, postero-median notch. Postero-supra-gnathal large and of a shearing type, with a well pronounced mesially directed process borne dorsally on the anterior half of the element. Antero-supra-gnathal unknown but necessarily either vestigial or completely absent. Infero-gnathal long and robust; its anterior functional division more than one-half the total length of the bone, with a distinctly thickened anterior symphyseal region on which occurs a single, low, oral den-

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ticle, a short, ventro-mesially produced extremity, and an entirely ventral articulatory surface for the antero-infero-gnathal; and with the external face worn by the opposing postero-supra-gnathal into a very deep and semicircular area.

Medio-dorsal plate wider than long; the outline of its thin, extended superior plate marked anteriorly by a broadly rounded median process and a pair of attenuated lateral ones, marked laterally by a shallow notch, and posteriorly by a short, slender, backward projection in the median line; its ventral keel weak, developed only posteriorly, where it is produced postero-ventrally in a short slender process which does not reach the transverse plane of the hind margin of the element, and which is dorsally ridged to separate a pair of shallow postero-ventral concavities in the dorsal plate. Antero-lateral plate triangular with the antero-dorsal margin but slightly concave, and with the acute antero-ventral angle divided longitudinally into both a strong internal arm for the support of the intero-lateral, and a well developed, although somewhat reduced lateral arm. Spinal plate probably completely atrophied. Antero-ventro-laterals, although longer than wide in actual dimensions, to be considered short and broad compared to the long, narrow postero-ventro-laterals. Postero-medio-ventral moderately enlarged.

Genotype.—*Bungartius perissus,* sp. nov.

Bungartius perissus, sp. nov.

Diagnosis.—The same as for the genus (the only species).

Holotype.—No. 7573, Cleveland Mus. Nat. Hist.: a dorso-ventrally crushed and practically complete assemblage of bones from a single individual, prepared and mounted as contained in a coarsely laminated concretion; from the Cleveland Shale member, Ohio Shales formation of the Upper Devonian on the West Branch of Rocky River, three-quarters of a mile upstream from the Lewis Road Bridge (Berea Quadrangle), Cuyahoga County, Ohio; collected on June 22, 1943, by David H. Dunkle and Peter A Bungart.

Description.—In proportions the over-all length of the cranial shield, from the rostral tip to the hind margin of the paranuchal, is only slightly less than the maximum posterior width measured over the greater external curvature. Its median dorsal length and its width dorsally across the pre-orbital processes are roughly three-quarters and two-thirds, respectively, of the approximately equal maximum dimensions of length and breadth given below (page 111). Compared to the other members of the Cleveland Shale fauna the cranial shield is long and narrow. Its median portion, behind the plane of the postorbital processes, is short. The postero-dorso-lateral extensions to the condylar fossae are only moderately long and the

unarmored nuchal notch in the posterior margin of the shield is considerably broader than long. Postero-ventro-laterally the postmarginal tips have only a shallow expansion. The orbits, whose horizontal diameter approaches one-third the over-all length of the shield, are situated laterally. The snout exhibits a remarkable pre-orbital production equal to fully one-third the length of the roofing complex.

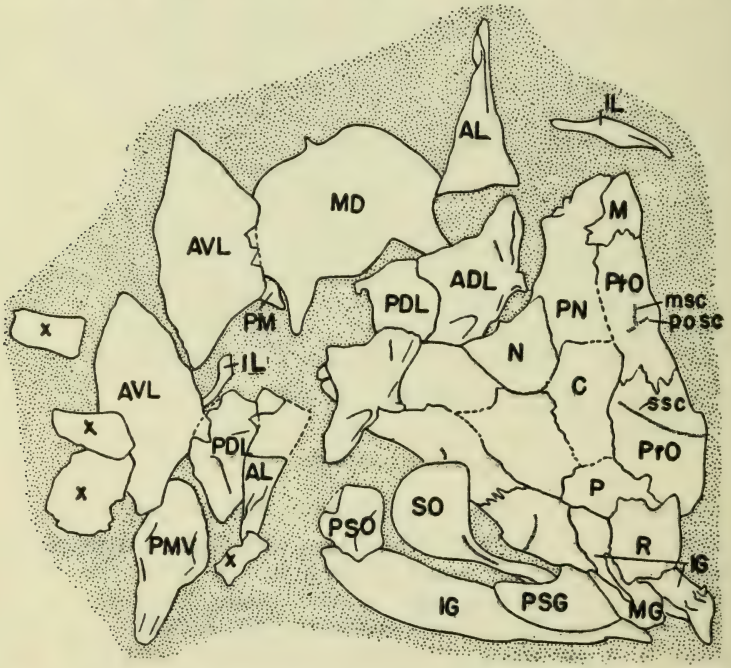

FIGURE 1.—*Bungartius perissus* Dunkle (No. 7573, C. M. N. H.). Sketch of the holotype as preserved in a concretion. Reproduction slightly less than x 1/8.

Explanation of Symbols—ADL, antero-dorso-lateral; AL, antero-lateral; AVL, antero-ventro-lateral; C, central; IG, infero-gnathal; IL, intero-lateral; M, marginal; MD, medio-dorsal; MG, medio-gnathal; msc, marginal sensory canal; N, nuchal; P, pineal; PDL, postero-dorso-lateral; PM, post-marginal; PMV, postero-medio-ventral; PN, paranuchal; PSO, postsuborbital; posc, postsuborbital sensory canal; PrO, pre-orbital; PSG, postero-supra-gnathal; PtO, postorbital; R, rostral; SO, suborbital; ssc, pre-orbital sensory canal; X, undetermined fragments.

As regards the component elements of the cranial shield, the nuchal plate is proportionately small, with an obtusely pointed anterior margin, and without any apparent extension of its postero-lateral angles. The paranuchals are 3 times longer than wide. The

condylar fossae, occupying their margins postero-dorsally, are broad, shallow concavities whose dorsal lips are more produced than the ventral ones. Their glenoid processes are exceptionally stout, although not greatly extended in length. The centrals display the usual irregular outline. The greatest width of each is somewhat more than one-half the maximum length, and they are in contact with each other for their total median length. The pineal is large and quadrangular. The rostral, also enlarged, is slightly longer than wide, and its anterior margin is marked by a peculiar and unexplained

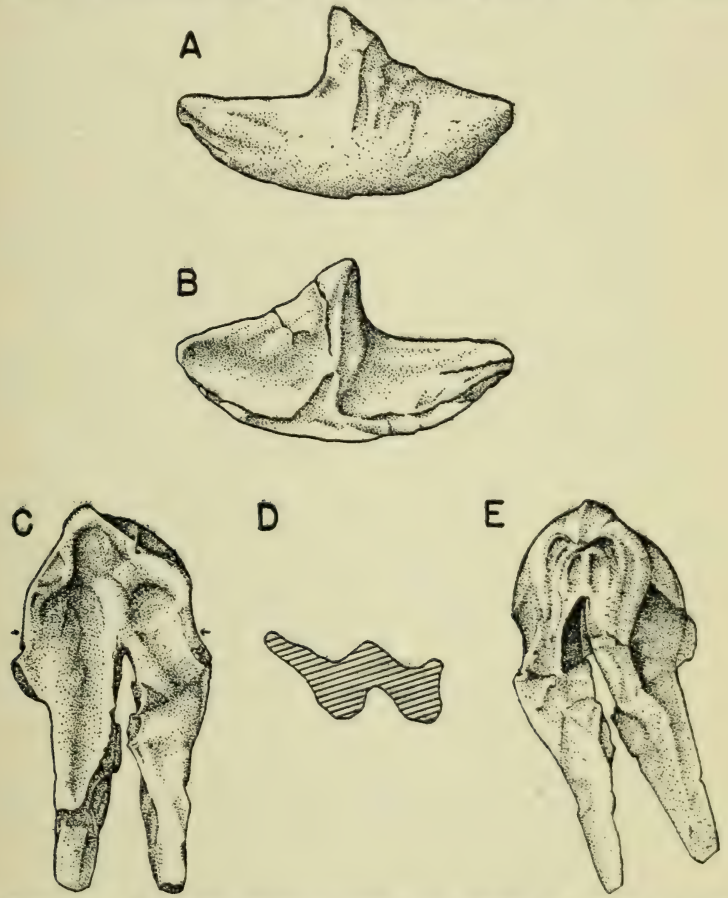

FIGURE 2.—*Bungartius perissus* Dunkle (No. 7573, C. M. N. H.). Right postero-supra-gnathal in (A) external; and (B) internal views. Reproduction approximately x ¼. Medio-gnathal in (C) dorsal; (D) transverse section at plane indicated by arrows on C; and (E) ventral views. Reproduction approximately x ½.

low rounded thickening on each side of the median line. The pre-orbitals, the largest elements of the shield, are somewhat longer than wide and have two-thirds of their ventro-lateral margins lying in advance of the weak pre-orbital processes. The postorbitals are likewise relatively much enlarged, 3 times as long as wide, and with prominent postorbital processes situated near the middle length of their ventro-lateral margins. The marginals are exceptionally reduced and restricted to a remote postero-ventro-lateral position widely separated from sutural contact with the centrals. The postmarginal plates are tiny and triangular.

The suborbitals, rather low in proportion to their lengths, have the vertically expanded, posterior blade portion occupying only one-third the length of the element. The blade parts are somewhat higher than long, and their posterior margins are broadly rounded. The anterior, infra-orbital 'handles' are remarkably long and low. A heavy, longitudinal flange is borne mesially here, the thickness of which exceeds the depth of the external face of the part. The post-suborbitals, triangular in their exposed area, approximate in size the blade portion of the anteriorly adjacent suborbital plates.

The medio-gnathal is remarkable for a general enlargement and proportionately extreme elongation. A short, heavy, anterior part bears orally a large median projection which shows lateral grooves worn by the ventrally opposing single, antero-dorsal denticles of the infero-gnathals. The extended posterior extremity is thin, and divided from the rear by a narrow notch for more than two-thirds its length into slender lateral prongs. The entire dorsal surface of the bone is roughly excavated for ventral articulation with the ethmoidal portion of the cartilaginous braincase. The postero-supra-gnathal is large and of a shearing type. In any frontal section, the element is longitudinally straight and of practically uniform thickness. Transversely, an external convexity and complementary internal concavity are pronounced. In lateral profile, the oral border is broadly convex, and the plate is deeper anteriorly than posteriorly due to the mesially directed process arising from the entire forward half of the dorsal margin. This process progressively increases in height, from front to back, to an apex situated near the middle of the length of the element. The antero-supra-gnathals are unknown, but from the small space remaining in their normal position when all the preserved mouth parts are assembled in exact association, they must necessarily have been either exceedingly vestigial or quite wanting. The infero-gnathals are comparatively large. They are but slightly arched downward along their long axes, and taper from a maximum posterior depth contained about 5 times in the total length of the plate forward to a minimum anterior depth of one-ninth that

length. The anterior functional division is somewhat longer than the posterior blade part. Its external face uniquely displays a deep, crescentic area worn by the postero-supra-gnathal. In the symphyseal region, the element is strengthened by a heavy vertical ridge, on top of which, orally, a single, low, conical denticle is borne; below which the thickened margin comprises an entirely ventral articulatory surface for the antero-infero-gnathal; and forward from which the element terminates in a short, ventro-mesially directed extremity.

The dorsal body armor is very short, but in keeping with the proportion of the head is low and narrow. The medio-dorsal is considerably wider than long. In outline, the anterior margin is trifid with a gently rounded median process and a somewhat longer but much slenderer one on each side; the lateral margins are shallowly

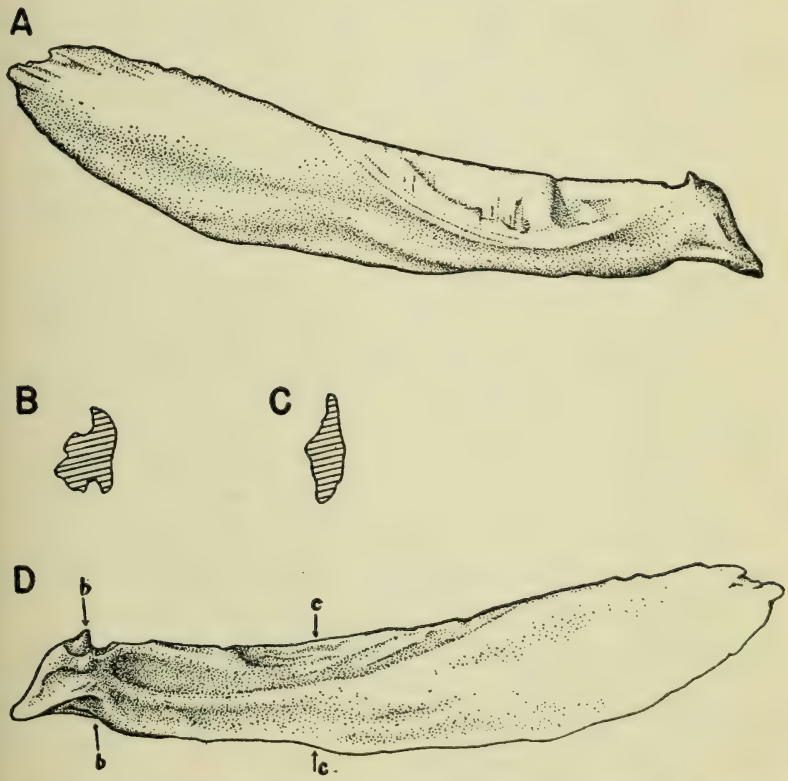

FIGURE 3.—*Bungartius perissus* Dunkle (No. 7573, C. M. N. H.). Right infero-gnathal in (A) external; (B and C) transverse sections in planes b-b and c-c, respectively, indicated on D; and (D) internal views. Reproduction approximately x ¼.

emarginated; the posterior edge is rounded and in the median line exhibits a short backwardly projecting tip. The ventral keel on the medio-dorsal is weak, and is developed only posteriorly where a slender, dorsally ridged projection extends down and backward. This posterior termination of the keel does not reach beyond the margin of the dorsal plate and tends merely to separate a pair of peculiar concavities below the border of the element. Both the antero-dorso-lateral and postero-dorso-lateral are large. Each is about twice as high as long, with the greatest longitudinal expansion in the dorsal half. The vertical anterior margin of the antero-dorso-lateral is not much thickened and the horizontal condyle is weak and flange-like. The antero-laterals are triangular with only a brief expansion of the postero-dorsal lamina and exhibit only a slight concavity in the antero-dorsal border. The antero-ventral shank of the bone is divided into both internal and external arms, the latter weaker than the former but still well developed. The spinal plates are, presumably, completely atrophied and the postero-laterals have not been identified. The intero-laterals are long, slender, and possess the characteristic ventral thickening and the thin, dorsally erected plate.

The ventral armor, long and narrow, does not evidence the same amount of reduction as the dorsal body complex. Of the median elements only the postero-medio-ventral has been determined. This bone is moderately large and diamond-shaped. Its length is twice its greatest width and is three-quarters of the length of the antero-ventro-lateral. The antero-ventro-laterals are twice as long as wide but only two-thirds the length of the postero-ventro-laterals. They are produced far antero-mesially but the lateral spinal processes are scarcely indicated. The postero-ventro-laterals are exceptionally long and narrow, with the maximum width contained 3 times in the over-all lengths of the elements.

Aside from the radiating lines of ossification on all bones, and a few indistinct concentric growth rings on the ventral plates, there is no preserved evidence of an ornamentation of the bones. The lateral line sensory canals are poorly preserved, and only the remnants shown in Figure 1 are decipherable.

Measurements.—The dimensions of the various complexes of bones and single plates of the 2 known specimens of *Bungartius perissus* are as follows:

	Spec. No. 7573, C. M. N. H. (Type)	Spec. No. 6666, C. M. N. H.
	cm.	*cm.*
Cranial shield		
Over-all length from the rostral tip to the hind margin of the paranuchal	40.5	.....
Medio dorsal length	33.0	.....
Maximum width measured posteriorly between the postmarginal tips over the greater externo-dorsal curvature	41.5	.....
Width dorsally across the pre-orbital processes	28.0	.....
Medio-dorsal		
Maximum length	20.2	11.0
Maximum width	25.0	13.2
Antero-dorso-lateral		
Maximum height	18.4	.....
Length at the horizontal plane of the condyle	9.8	.....
Antero-ventro-lateral		
Length	28.0	16.3
Width	12.0	9.5
Postero-medio-ventral		
Length	20.5	14.0
Width	9.3	5.1
Postero-ventro-lateral		
Length	.....	22.7
Width	.....	6.6

Referred Specimens.—The type; also No. 6666, Cleveland Mus. Nat. Hist., consisting of a number of disassociated dorsal and ventral armoring plates contained in a cone-in-cone concretion; from the Cleveland Shale member, Ohio Shales formation of the Upper Devonian on the West Branch of Rocky River (Berea Quadrangle), Cuyahoga County, Ohio; collected on September 16, 1936, by Peter A. Bungart.

Remarks.—The osteology of *Bungartius perissus*, for one of the presumed rarities within the Cleveland Shale arthrodiran fauna, is surprisingly well revealed in these 2 sole specimens available for study. In the possession of the combined characters listed in the

above diagnosis, the form is without parallel among its local contemporaries, except possibly *Diplognathus*, and it appears unique even among all euarthrodirans.

This new genus *Bungartius* shares in common with all the other better known members of this specialized and culminating assemblage of North American arthrodires, an extreme postero-median shortness of the cranial shield postorbitally, with a relatively great postero-

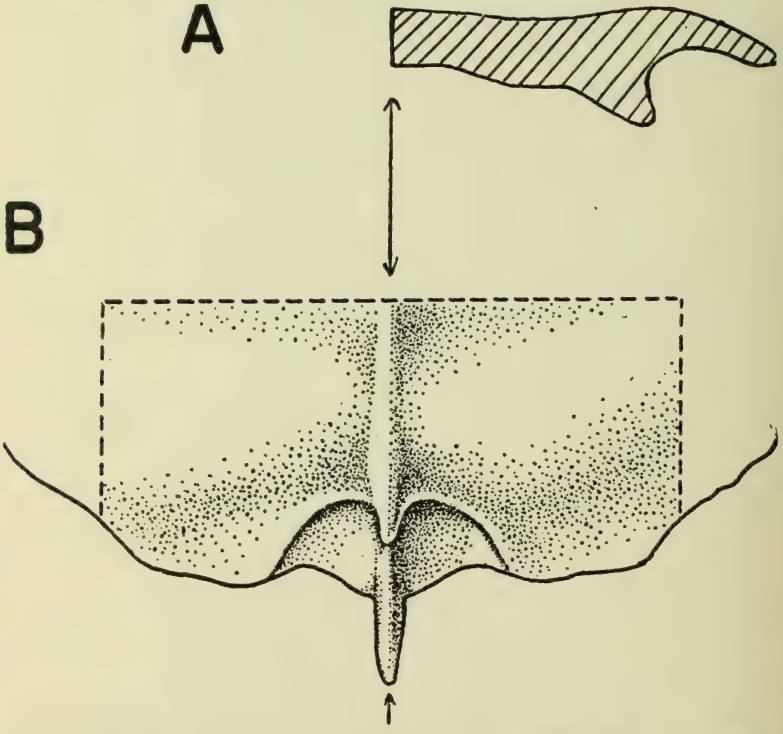

FIGURE 4.—*Bungartius perissus* Dunkle (No. 6666, C. M. N. H.). Postero-median portion of the medio-dorsal plate in (A) longitudinal section; and (B) ventral view. Reproduction approximately x ½.

lateral extension of its margins containing the condylar fossae. For what they reflect of the probable proportions of the braincase, these conditions alone discourage search for relatives of *Bungartius* among either the leptosteids, brachydirids, or oxyosteids from the Upper Devonian of Europe which possess narrow, elongated dermal armor with a snout development of greater or less degree[3].

[3]Gross, Geol. Pal. Abh., (N.F.) XIX, Heft 1, 1932, pp. 5-61, 2 pls., 26 figs.

Among the Cleveland Shale arthrodires the various coccosteids and dinichthyids are manifestly not related. The only medio-gnathals possessing an enlargement approaching that of *Bungartius* are those which currently bear the name *Dinognathus*[4]. In contrast to *Bungartius*, the latter are broad crushing plates, whose entire oral surface shows evidence of functional wear. The *Dinognathus* type of medio-gnathal has always been found isolated, and while certain doubts must be entertained regarding the correctness of the association[5], the bones have always been referred to the Mylostomidae. However, *Bungartius* can scarcely be considered closely affined to these arthrodires so distinctively adapted for a mollusk feeding habit.

It is thought that the selenosteids and *Trachosteus* similarly may be eliminated as possible relatives of *Bungartius*. The selenosteids are small, broad-headed forms with practically no rostral development; large forwardly placed eyes; vastly different mouth parts; heavily keeled medio-dorsals; and with antero-laterals, which in at least *Gymnotrachelus*[6] and *Paramylostoma*[7] have present only the external arm in its antero-ventral shank. It is presumed that *Trachosteus* has a medio-dorsal plate rather similar to that of *Bungartius*[8], but in addition to marked differences between their respective cranial shields, suborbital plates, and gnathal elements, the bones of *Trachosteus* are highly ornamented. Externally ornamented bones are commonly possessed by most early euarthrodiran fishes, but the tuberculations become obsolete in the later representatives of many phylogenetic lines. This seems to have been accomplished by the dermal armor's partially invading the cartilaginous internal skeleton and sinking to deeper levels. So-called 'denticulated' gnathal bones are another problem which will be discussed at a later time. Certain strengths were gained by the consolidation of the dermal and primary skeletal components, and these may have been one of the chief factors permitting the reduction in the amount of dermal bone seen in the brachythoracine arthrodires. While reduction in the amount of armored body surface without the loss of external ornamentation certainly obtained in some cases, such a condition appears definitely the exception within the Ohio Shales fauna. For this reason, the loss of ornamentation is here thought to have greater morphological and phylogenetic importance than perhaps it has been accorded.

Omitting *Aspidichthys* as a probably holonemid, and *Glyptaspis* as a too inadequately understood ornamented, form, there alone remain for consideration in the local fauna the titanichthyids and

[4]Hussakof, Bull. Amer. Mus. Nat. Hist., Vol. XXVI, Art. 20, 1909, pp. 268-270, fig. 5.

[5]Dunkle and Bungart, Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 9, Dec. 12, 1945, pp. 97-102, figs. 1-2.

[6]Dunkle and Bungart, Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 2, Dec. 14, 1939, pp. 13-28, pl. III, figs. 1-6.

[7]Dunkle and Bungart, Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 8, Dec. 8, 1945, pp. 85-95, figs. 1-3.

[8]Dean, Mem. Amer. Mus. Nat. Hist., Vol. IX, 1909, pp. 272-276, pl. XLI, figs. 56-57.

Diplognathus. The titanichthyids are a very poorly known group. Currently included among them is a variety of infero-gnathal types, all of which, reminiscent of the condition in *Bungartius*, exhibit anterior extremities directed forwardly and ventro-mesially. Some of these titanichthyid mandibular elements have never been associated with any other plates. Others have been found with suborbitals, antero-dorso-laterals, and antero-laterals so variously modified from

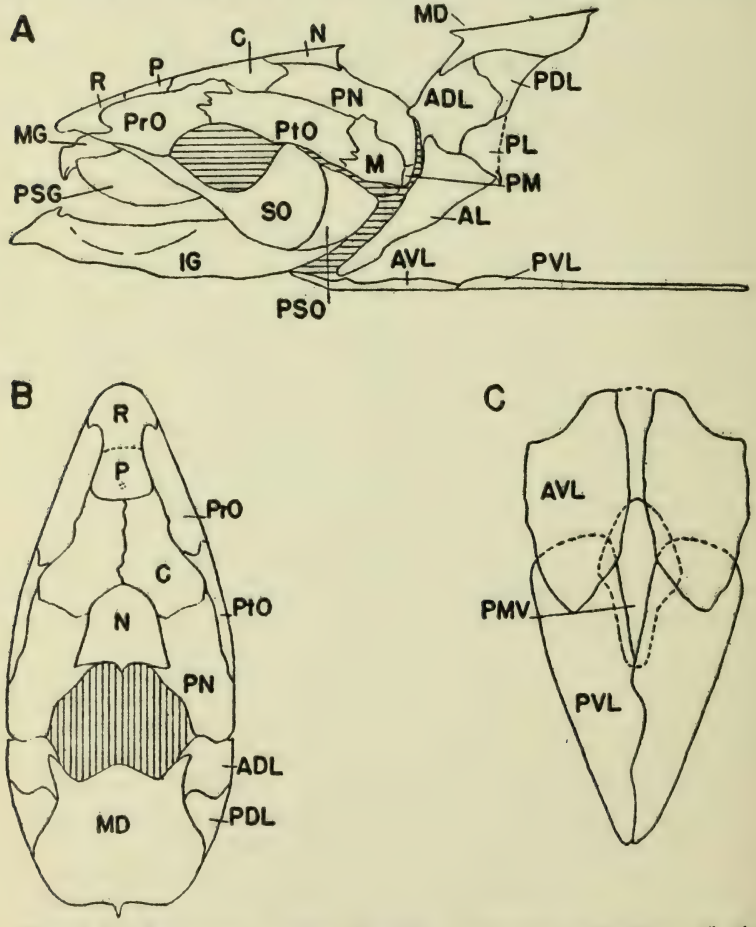

FIGURE 5.—*Bungartius perissus* Dunkle. Attempted restoration of the head and body armor in (A) lateral; (B) dorsal; and (C) ventral views. Reproduction approximately x 1/8 the size of the type specimen.

Explanation of Symbols.—PL, postero-lateral; PVL, postero-ventro-lateral; and others as in Figure 1.

each other that if collected separately, it is doubtful if their titanichthyid nature would even be recognized. In consequence, *Titanichthys clarkii* Newberry alone of the entire group is known to have in addition to the infero-gnathals, structures similar to those of *Bungartius*. In these two the medio-dorsals, antero-dorso-laterals, antero-laterals, and suborbitals are of almost identical development. However, *Titanichthys clarkii* is a very broad, depressed form with large but forwardly situated orbits. It shows no evidence of a rostral extension. In fact, to this writer's knowledge, the rostral plate of *Titanichthys* has never been identified. On the cranial shields available to the present writer a broad vacuity occupies its position, anterior to the pineal and mesial to the pre-orbitals. The anterior tips of the infero-gnathals, when those elements are correctly aligned, lie just in advance of the transverse plane of the pre-orbital processes. From these facts, until different evidence is produced, there is no reason to believe other than that the mouth, although ventrally opening, was but more than slightly subterminal. Further, comparing these two, the mechanics of the jaws are seen to be of a different order. This is shown by the variant proportions between the lengths of the functional and blade portions of the infero-gnathals. Also from known remains it may be presumed that the ventral armor of *T. clarkii* had undergone marked reduction. The distinctive titanichthyid modification had already been well established by the beginning of Upper Devonian times. If the similarities between *Bungartius* and *T. clarkii* may be taken as phylogenetic affinity, the relationship must have been indeed remote.

Regarding *Diplognathus*, only the suborbital, postero-supra-gnathal, and infero-gnathal plates of that genus are known in detail[9]. As previously discussed, the length of the posterior, inserted portion of the infero-gnathal closely reflects the marginal length of the arthrodiran head shield postorbitally, since the jaw muscles originate on the latter and are inserted on the former[10]. It can be inferred, therefore, that the head of *Diplognathus* was very short behind the orbits because of the shortness of the posterior blade part of its infero-gnathal. While not necessarily conclusive, an accompanying lowness of the head may be postulated from the horizontal straightness along the longitudinal axis of the infero-gnathal and by the shallow depth of the vertically expanded, posterior lamina of the suborbital. A narrowness of the dermal armor in *Diplognathus* is shown by the narrow posterior divergence of the infero-gnathals when the symphyseal surfaces of those bones are aligned together. The anterior dorsal emargination of the suborbitals denotes moderately large eyes. The long anterior and orally functional production of the infero-gnathal

[9]Dunkle and Bungart, Scient. Publ. Cleveland Mus. Nat. Hist., Vol. VIII, No. 7, Dec. 31, 1943, pp. 73-84, figs. 1-4.

[10]Dunkle and Bungart, Amer. Mus. Novit., No. 1316, April 3, 1946, pp. 1-10, figs. 1-4.

indicates both that considerable rostral development was present and that the orbits were laterally situated. Such proportions and configuration of parts are strikingly similar to the modifications found in *Bungartius*. Here, too, may be mentioned the comparable mesial flanges on the infra-orbital 'handles' of the suborbitals in both forms, once interpreted for *Diplognathus* as a means of increasing the cross-sectional area of small, posteriorly restricted jaw muscles.

From the meager material of *Diplognathus* yet available attention can be called to only 2 morphological features which vary widely between that genus and *Bungartius*. The presence or absence of 'denticles' on the gnathal elements is disregarded as subject to radical modification with age and wear. The first of these 2 marked differences is seen in the relative sizes of the postero-supra-gnathal bones. Large in *Bungartius*, the postero-supra-gnathal in *Diplognathus* is very short. The anteriorly succeeding length of the infero-gnathal of *Diplognathus* to be opposed by the antero-supra-gnathal and medio-gnathal, consequently, is exceptionally long. Speculation is excited as to a possible enlargement of both the antero-supra-gnathal and medio-gnathal or of one at the expense of the other. Secondly, the infero-gnathal of *Diplognathus*, in contrast to that of *Bungartius*, may be said to be in a manner cuspidate. Its extremity is extended forwardly and somewhat dorso-mesially.

More complete specimens of *Diplognathus* must be found before the structural similarities between it and *Bungartius* can be said definitely to denote phylogenetic relationship any more than they might indicate convergent responses to similar although independent adaptations. The noted variations between the mouth parts, however, are of no greater magnitude than those existing between the 2 closely related members of the *Dinichthys herzeri* group, *Heintzichthys* and *Gorgonichthys*[11], both of which had weak jaw muscles. *Heintzichthys*, on the one hand, decreased the size of its antero-supra-gnathal and reduced the height of the anterior infero-gnathal cusp while increasing the length of the postero-supra-gnathal and its ventrally opposing infero-gnathal border. In *Gorgonichthys*, on the other hand, quite the reverse modification obtained. All the available force was concentrated into one point by the magnification in

[11]Dunkle and Bungart, Amer. Mus. Novit., No. 1316, April 3, 1946, pp. 1-10, figs. 1-4.

height of the anterior infero-gnathal cusp and enlargement of the opposing antero-supra-gnathal. It does not seem unlikely that a positive relationship between *Diplognathus* and *Bungartius* ultimately will be proved.

The determination of the antecedents of neither *Diplognathus* nor *Bungartius* can be made satisfactorily at this time. In the past, attempts were made to relate *Diplognathus* variously with *Glyptaspis* and *Trachosteus,* the mylostomids, and the selenosteids. From the foregoing comparisons and previous studies, it can be seen that this writer is not inclined toward any of these arthrodires as probable relatives. For the present it is considered necessary to regard these 2 genera as Brachythoraci of uncertain systematic position.

BULLETIN NUMBER 1.
THE HOLDEN ARBORETUM

SCIENTIFIC PUBLICATIONS OF THE
LEVELAND MUSEUM OF NATURAL HISTORY

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ISSUED JANUARY 1949

The Native Forests of Cuyahoga County, Ohio

By

ARTHUR B. WILLIAMS, Ph. D.

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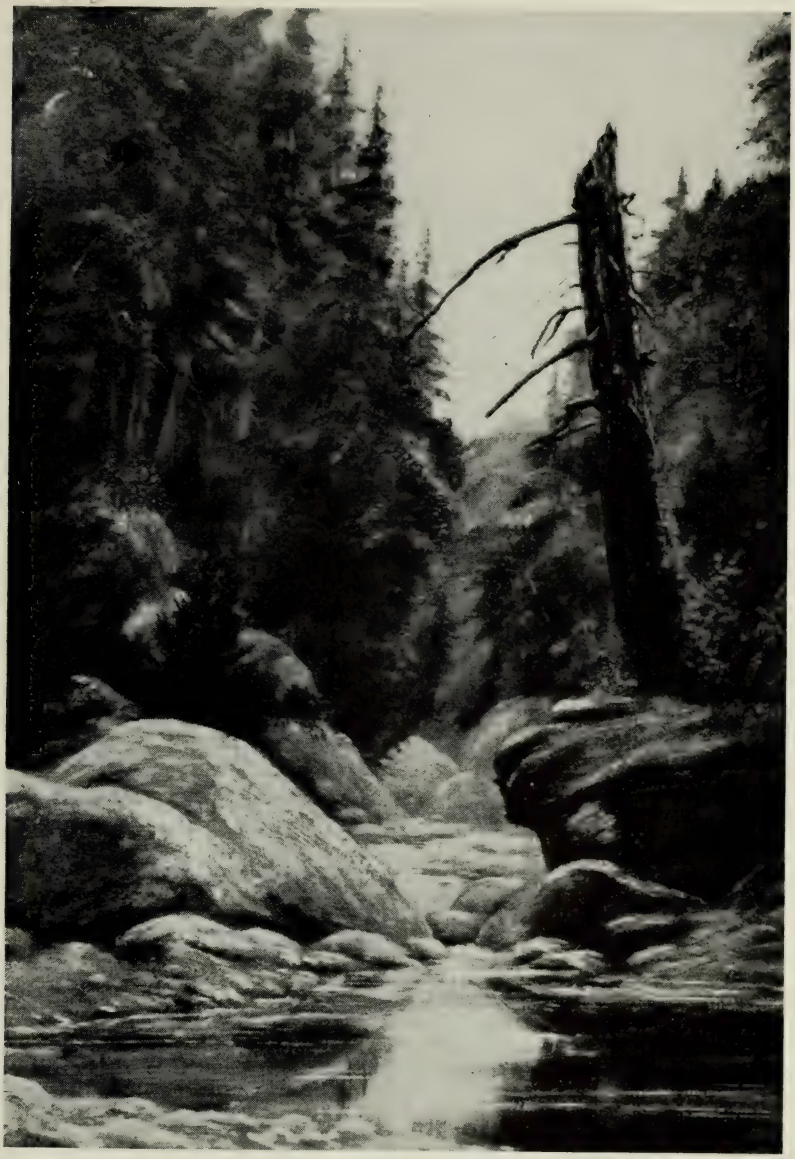

Frontispiece — Chippewa Creek Gorge in 1860, showing dense hemlock forest. Now in Brecksville Metropolitan Park. From painting by F. H. Dart of Oberlin made in 1900. *Courtesy of Mrs. Walter Lister.*

The Native Forests of Cuyahoga County

I.

INTRODUCTION

This study was undertaken in order to determine, as accurately and in as much detail as possible, the character and composition of the forest cover of Cuyahoga County, Ohio, as it existed at the time when the first white man entered it.

While there are a few records of white men on the banks of the Cuyahoga River previous to the arrival of Moses Cleaveland and his band of surveyors in 1796, we may take this date as representing a time when the native forest then occupying the land might be considered to have been modified little, if any, by human agency. This was true of Cuyahoga County even with reference to Indian influences, since for many years this part of Ohio had been a sort of "no-man's-land" from the standpoint of the Indian tribes, which regarded the area mainly as a hunting territory so dubious that at any time it might turn out to be a battleground. (Whittlesey, 1867; Wilcox, 1933).

The date 1796 carries us back from the time of the present writing only 152 years. Since many forest trees in this region are known to have attained ages in excess of 300 years, it is evident that some remnants of the forests of Moses Cleaveland's day may still be in existence, as in fact they are. The time has come, however, when many old trees that have long stood as landmarks have disappeared, and the number of survivors of the forests of 1796 is becoming rapidly less. As time passes, the task of reconstructing the picture of the "original forests" becomes increasingly difficult.

Studies of this sort have already been made in Ohio for the counties of Athens (Boetischer 1929), Pickaway (Shupe 1930), Allen (Murray 1930), Logan (Diller 1932), Ashtabula (Hicks 1933), Meigs (Jones 1936), Ross (Crowl 1937), Wood and Henry (Shanks 1939), Geauga (Crittenden 1940), Trumbull (Shanks 1942). These are in the form of theses for advanced degrees in the Department of Botany, Ohio State University.

The natural vegetation of the entire state has been studied and outlined in a general way by Sears (1925, 1926), and Sampson (1927). In other states, the study of the natural vegetation of Cattaraugus County, New York, by Gordon (1940) is an outstanding example.

The value of such studies lies in the fact that they contribute to our understanding of the environment in which the civilization of the present day had its origins, and in which, though now greatly modified, we, in these latter days, live. Anything that helps mankind to a better adjustment to his environment is a contribution to human welfare and happiness. Such

studies, taken together, add to our knowledge of the forces that determine the character and distribution of plants throughout the land. They are of immediate interest to ecologists, botanists, foresters, conservationists and historians. For the student of natural history an understanding of the natural vegetation of any region is a prerequisite to the understanding of its present day fauna and flora, and often furnishes the basis for the explanation of facts which may otherwise seem completely baffling.

One of the real pleasures incident to the making of this study has been that of forming the acquaintance of a large number of people who really love trees. This was particularly true during the search for isolated large old trees within the built-up portions of the cities of the county. Many of these oldsters were trees loved for their association with family history or tradition and carefully cherished by present-day owners.

Acknowledgments are due especially to the following, who have aided by their advice and information relative to past conditions as they recalled them or as family tradition pictured them: Charles K. Arter, B. P. Bole, Jr., Nelson J. Cotabish*, Dr. T. D. Gould, C. H. Excell, Clarence Hutchinson*, Charles W. Irish, Frank D. Johnson, Don Knowlton, Mrs. Walter Lister, George Mastick*, Mrs. G. H. Michel, John Ord*, J. W. Saffold, Albert Smith, Oliver Upson*, Charles Willard, H. E. Willard*.

My thanks are also due to a long list of accommodating people who aided by reporting the locations of over 280 individual large trees in response to newspaper and radio publicity.

An annotated list of trees native to Cuyahoga County will be found in the section at the back of the book. This list is intended as an aid to students of our local trees who may want to become familiar with them as species, and to know something of their relationships and place in the picture of Cuyahoga County's native forests. Included under each species is a reference to a locality where it may be found within easy reach of Cleveland. For the sake of completeness, and because so many of them occur along our city streets or in parks, a list of the more common introduced tree species has also been included. Photographs, unless otherwise specified, have been taken by the writer.

*Since deceased.

II.

LOCATION, TOPOGRAPHY, SOILS, DRAINAGE

Since the character of the forest cover of any given area is largely determined by such things as topography, soil, drainage and climate, and since these factors in Cuyahoga County are exceedingly varied, it will be useful in this study, first of all, to examine these conditions as they occur in the county at the present time.

Cuyahoga County, Ohio, lies on the northern margin of the state, having a frontage of approximately 28 miles along the southern shore of Lake Erie. From east to west its greatest width is about 31 miles; from north to south through its central portion, about 16 miles. Its total area is in the neighborhood of 453 square miles, or 289,920 acres. Parallel 41°25′ of north latitude passes through its central portion. Lake Erie, upon which it borders, stands at 573 feet above sea level; and the county's highest point, near its central southern limits, is 1280 feet above sea level, thus making a rise of 707 feet from lake level to heights.

Cuyahoga County is so situated that it includes within its boundaries portions of two of the great physiographic provinces of North America. Approximately two-thirds of its area is included within the western limits of the Appalachian Plateaus Province, while the other third lies within the Central Lowlands Province. The Portage Escarpment, which separates the two provinces in this region, passes through the county in a northeasterly southwesterly direction. The base of the Portage Escarpment within the county in its northeastern section is indicated in a general way by the line of Euclid Avenue from the eastern county line to University Circle, City of Cleveland. As the escarpment here turns southerly into the Cuyahoga Valley, its base may be located along the lines of Woodhill Road, East 93rd Street, Warner Road, and the eastern boundaries of Valley View Village, which roughly follow the crest of the first steep rise from the valley floor. As the escarpment emerges on the west side of the valley it may be picked up along Rockside Road, from the western end of which it curves west and southwest to meet the line of Pearl Road. From this point, following the line of Pearl Road, it passes out of the county in its southwestern corner. Thus the lowland portion of the county occupies its northern and western sections; the plateaus portion, the eastern and southern parts. The entire land surface of the county has been subjected to glaciation several times, the last, or "Wisconsin" stage of glaciation coming to a close in Ohio some 20,000 to 25,000 years ago. (Cushing, Leverett and Van Horn, 1931).

Because, within the county, the plateaus section is bisected by the broad valley of the Cuyahoga River, which here flows northwesterly into Lake Erie, this part of the county is separated into two relatively high land masses, one making up its eastern, the other its southern portion. The eastern highlands is also cut by a river valley, the Chagrin, along the eastern edge of the county. Likewise the southern highlands is cut in the southwestern corner of the county by the valley of the East Branch of Rocky River.

Most of that part of the county included within the central lowlands portion is known locally as the Erie Plain. This plain is limited to the

areas formerly occupied by the bottoms of glacial lakes during the withdrawal of the Wisconsin ice sheet. It is also often referred to as the Lake Plain. This relatively level land stretches in a narrow strip from 2 to 3 miles wide between Lake Erie and the foot of the Portage Escarpment from the northeast corner of the county to the Cuyahoga Valley. From this point, as the escarpment bends toward the southwest, the Erie Plain widens to include practically all of the western portion of the county.

In the southwestern part of the county there is a small area of till plain that represents the extreme northeastern tip of the great till plain that covers most of southwestern Ohio.

Cuyahoga County's varied topography may then be summed up by saying that it is characterized by eastern highlands, southern highlands, western lake plain and till plain, and a further narrow strip of lake plain fronting on Lake Erie in the county's northeastern portion. The land is further sculptured by the drainage patterns of the three rivers mentioned, and by their numerous tributary streams, as well as by many shorter streams that reach the lake directly. Reference to Figure 1 will make clear these major topographic divisions of the county.

These features will now be considered more in detail with reference to their soils, drainage, and influence on the character of vegetation present upon them now and in the past.

1. The Eastern Highlands — This portion of the county (see Fig. 1) presents the features of a broad dome, with its two highest portions at about 1250 feet above sea level (677 feet above Lake Erie). These points are easily located as the site of the Tuberculosis Sanatorium at Warrensville, and the corner of North Miles and Harper Roads. Just south of this latter point a fine view of the Cuyahoga Valley to the southwest may be gained.

These high spots mark the former surface of the old Allegheny Plateau. From their flat tops the land slopes in all directions — more steeply toward the Chagrin Valley to the east — more gradually toward the Cuyahoga Valley to west and southwest, and toward Lake Erie to the north. Streams having their origins here flow in many directions as determined by the character of the immediate land surface, often reaching the lake by tortuous courses. Those flowing northerly for the most part find their way more directly into the lake. The waters of the others eventually reach the same destination either by way of the Chagrin or the Cuyahoga Rivers.

The valley of the Chagrin, with its often precipitous sides, exhibits numerous steep-walled, narrow, tributary gorges. The smaller streams, as they near the steeper grades of the escarpment edge, and as the underlying shales and sandstones are uncovered, also develop ravines and gorges

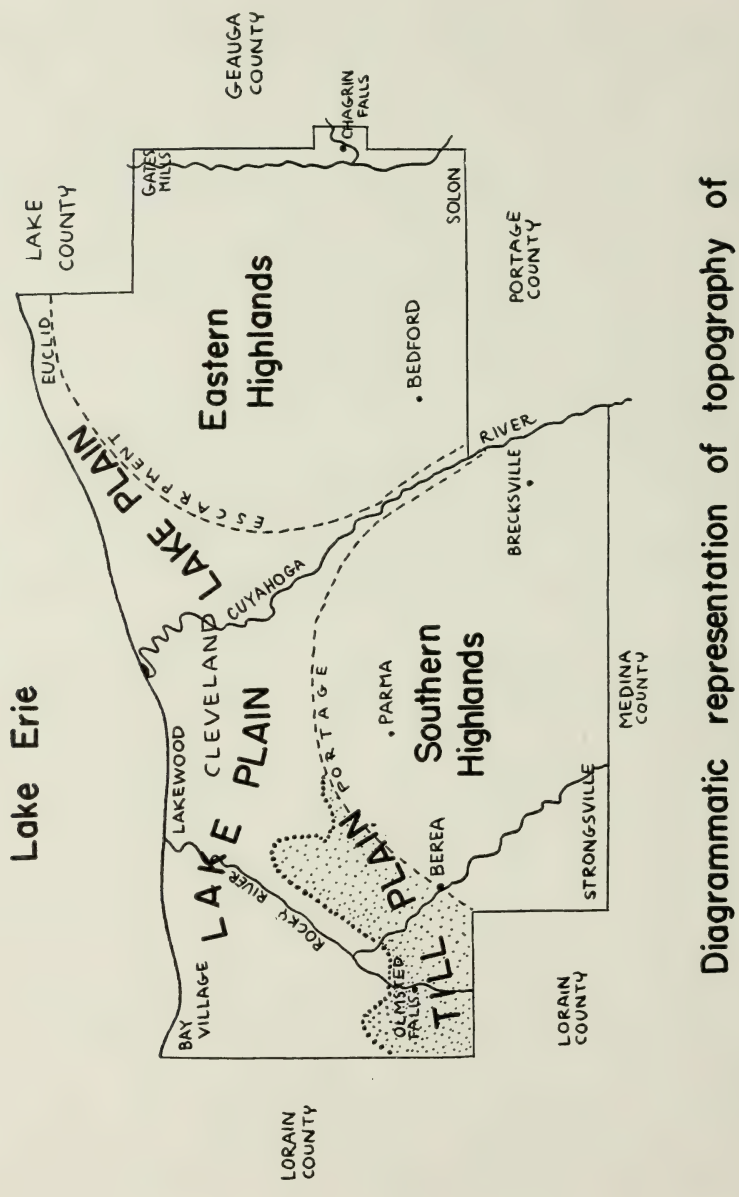

FIG. 1. Cuyahoga County. Diagram showing major topographic divisions.

that give a characteristically picturesque aspect to the region. The principal of these smaller streams are Euclid Creek (Green Road), Ninemile Creek (Belvoir Boulevard), Doan Brook (North Park Boulevard), Mill Creek (south of Broadway), and Tinker's Creek (Bedford Metropolitan Park).

Certain parts of these eastern highlands present surfaces of very low relative relief with poorly developed drainage. This is especially true of the southeastern corner of the county (Aurora Road), but holds good for many a smaller area as well. In such places, due to the dense character of the underlying clay, swampy ground is often developed, and it is certain that such places were much more common and more swampy in character 150 years ago than they are today.

The soils of the eastern highlands are of glacial origin, either of shale and sandstone materials such as cover most of northeastern Ohio, making a heavy clay loam, or in a few places a more sandy and gravelly soil, due to the presence of glacial moraines. The clay soils are poorly drained, not classed as among the more productive soils of the state, and usually characterized by the presence of beech trees. (Coffey and Rice, 1912).

2. *The Southern Highlands* — This portion of the county (see Fig. 1) again exhibits the dome-like character of topography previously noted for the eastern highland portion, except that it largely lacks the relatively flat, poorly drained areas such as characterize portions of the eastern highlands. Much of the land is more fully dissected by the streams, thus presenting a general ridge and valley topography. Its two highest points are near the corner of Ridge and Wallings Roads (1265 feet), and on the Brecksville-Rocky River Parkway connection just west of Broadview Road (1280 feet).

From these high points the slope of the land is much more gradual toward the north (Parma) than toward the east or west. On the east the approach to the Cuyahoga is much like that of the approach to the same valley westerly from the eastern highlands. On the west the approach to the broad valley of the East Branch of Rocky River is almost precipitous in the vicinity of York Road. Toward the north, however, the escarpment face extends a broad lobe out toward the lowlands, descending by easy slopes to the Lake Plain. Here the Portage Escarpment is difficult of recognition, except along the southerly edge of Rockside Road where it becomes a prominent feature of the landscape.

In this southern highlands portion of the county the headwaters of Big Creek begin their flow directly northward, but later become tributary to the Cuyahoga to the east. On the east slope the headwaters of Chippewa Creek, another tributary of the Cuyahoga, have their rise. On the south the head streams of the East Branch of Rocky River rise, to flow south,

until, circling Whipps' Ledges in Medina County, the stream turns northwest to enter Cuyahoga County again, cutting across the southwesterly edge of the southern highlands. To the west, the headwaters of Baldwin Creek flow westerly to join the East Branch at Berea.

The valley of the East Branch of Rocky River as a whole in this part of the county is broad, with gradual slopes, as compared with the often steep-walled valley of the Chagrin in the eastern highlands.

On the whole, the southern highlands are better and more completely drained than are the eastern highlands, which would indicate a lower water table. Both the Cuyahoga and the East Branch of Rocky River in this region are working in the soft glacial fillings of their ancient valleys, and have here developed wide valleys quite unlike those of the Chagrin or of Rocky River farther on toward Lake Erie. There are comparatively few places where swampy areas of any great extent could or have developed, although some smaller ones are known to have been present in earlier times. This region is therefore more xeric in character than the corresponding uplands of the eastern highland section.

In general, the larger land masses of the southern highlands present the features of long ridges extending in a northerly-southerly direction (Broadview, State, Ridge, and Abbey Roads), and the base of the plateau to the north is composed of the ends of these ridges spread out like the stubby fingers of a giant hand. Due to the broader character of the East Branch Valley, and the more gradual slope of the escarpment base toward the north, there is not the same spectacular development of short ravines and gorges in this section as in the eastern highlands. Toward the Cuyahoga, however, the gorge of Chippewa Creek, and of other smaller tributaries to this stream, have dissected the land quite fully.

The soils of the southern highlands are much like those already described for the eastern highlands.

3. *Escarpment Edge* — Inasmuch as the base of the Portage Escarpment within the county frequently appears as a steep and often precipitous slope, two special conditions are thus created that deserve attention. The first of these is the deep gorge, of which the principal are those formed by Euclid Creek, Doan Brook, Tinker's Creek and Chippewa Creek. In each of these the head of the gorge appears where the stream bed passes from a resistant sandstone (Berea Sandstone) to the softer shales (Bedford, Cleveland, and Chagrin Shales) below. From this point the gorge usually deepens rapidly, developing with steep sides until the foot of the escarpment is reached and the stream either enters the Lake Plain (Euclid Creek and Doan Brook) or the Flood Plain of the Cuyahoga (Tinker's Creek

and Chippewa Creek). The gorge itself is cool and moist due to the abundance of shade and the presence of the stream at its bottom.

The other type of environment created by the escarpment edge is that of the steep slope itself and especially of its higher parts, including the edge of the gorge. This is a rather unstable condition due to constant erosion, and, as there is little water-holding capacity in the underlying soil, it is quite xeric in character. Soils here are for the most part those derived directly from the underlying shales in which the forest cover must actually find its footing.

4. *The Lake Plain* — To the northeast the Lake Plain consists of a narrow strip of land, about 2 miles in width, lying between the escarpment base (Euclid Avenue) and the Lake Erie shore (see Fig. 2). This land is largely old lake bottom mantled with deposits of silts, sands and gravels. Its mid-portion is traversed nearly throughout its length by a sandy ridge representing an old lake beach (St. Clair Avenue beyond Collinwood). It is cut across by the shallow valleys of Euclid Creek, Ninemile Creek, and other smaller streams, most of which head back into the edge of the plateau. Along the lake shore the bluff is often nearly vertical, and consists largely of unconsolidated materials which form the filling of preglacial stream valleys. Through this material the smaller streams have developed short ravines just as they enter the lake.

This portion of the Lake Plain is relatively flat, with poor drainage, and formerly included many wet and swampy areas which have since been drained by human agency, and are no longer apparent.

Proceeding westward, the valley of the Cuyahoga River is reached, and the escarpment bends to the southwest. The Lake Plain here widens to include the filled-in delta of the preglacial Cuyahoga River. This constitutes the flat platform upon which the larger part of the City of Cleveland has been built (see Fig. 2). It consists of glacial, lake and river deposits of sands, gravels, clays, and silt. The underlying clays are very dense in character, while the overlying deposits are more porous. This allows water, percolating through the upper layers, to become impounded in pockets of the impervious clays below, thus creating wet and swampy areas, such as for instance formerly existed between Euclid Avenue and Kinsman Road in the vicinity of East 55th Street and in many another place now fully occupied by streets and buildings. On the other hand, this portion of the Lake Plain is also marked by numerous dry sandy ridges representing portions of old lake beaches (Euclid Avenue, Woodland Avenue, Detroit Avenue, Denison Avenue, Triskett Road, Hilliard Road, Schaaf Road), and is bordered on the south by a terminal moraine (Behrwald Avenue, Schaaf Road, south end of East 71st Street). (Cushing, Leverett and Van Horn, 1931).

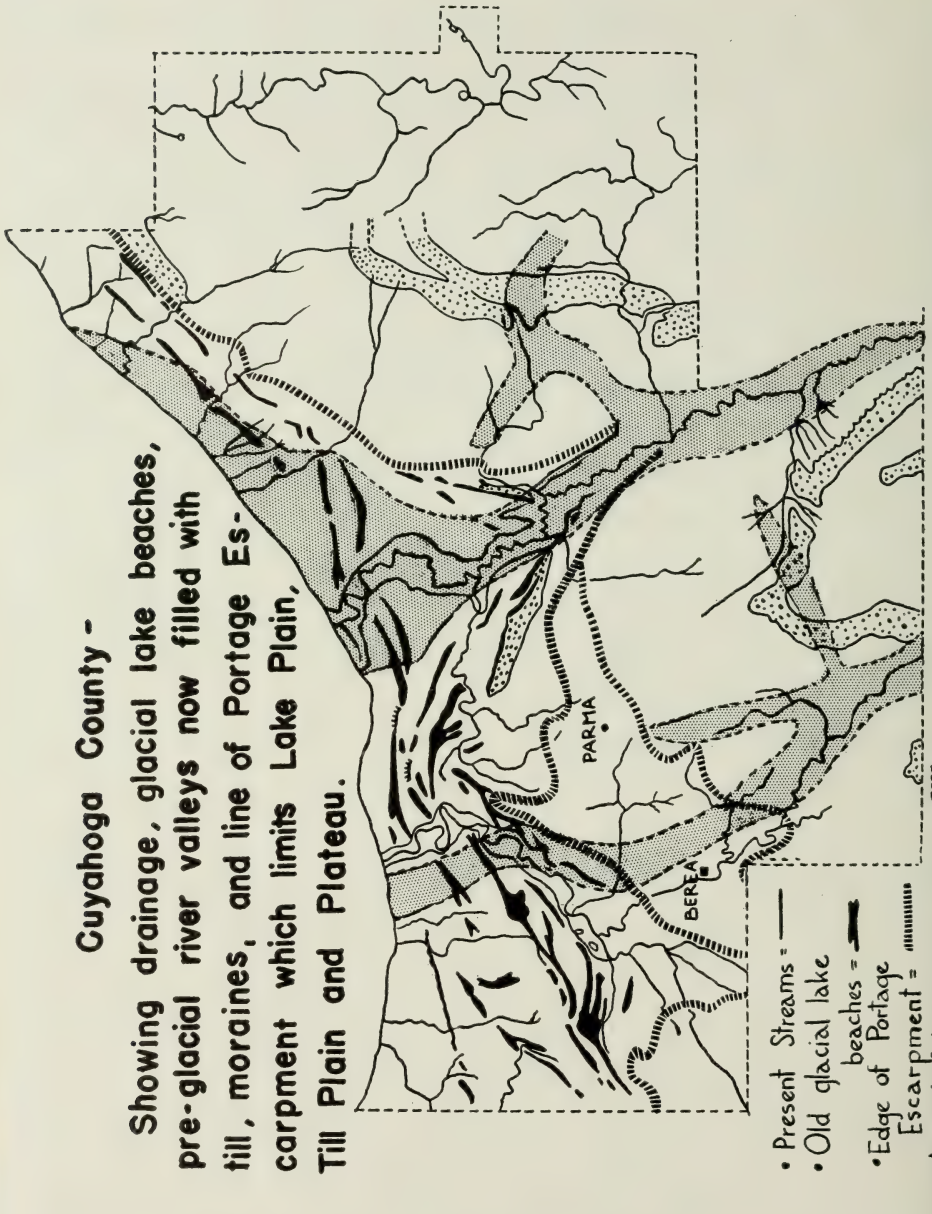
Cuyahoga County -
Showing drainage, glacial lake beaches, pre-glacial river valleys now filled with till, moraines, and line of Portage Escarpment which limits Lake Plain, Till Plain and Plateau.
PARMA
BEREA
• Present Streams =
• Old glacial lake beaches =
• Edge of Portage Escarpment =
• Ancient filled-in river valleys =
• Moraines =

FIG. 2. Cuyahoga County. Map showing drainage, glacial lake beaches, preglacial filled-in river valleys, moraines, and line of Portage Escarpment.

This part of the Lake Plain is bisected by the present Cuyahoga River, which since glacial times has cut a new and smaller channel through the river and lake deposits now filling its broad ancient valley. Many a smaller stream, of which Doan Brook is the chief, also crosses this plain in a shallow valley, and many have developed small ravines as they enter the lake. Streams tributary to the Cuyahoga (Kingsbury Run, Morgan Run, Burk Branch, Mill Creek, Big Creek) have deeply dissected the plain to the south. (see Fig. 3).

West of the City of Cleveland the Lake Plain widens along the western line of the county to a distance of about 9 miles. This portion of the plain is also a region of low relief, but is traversed by several great old lake beaches throughout its length. These beach lines now carry important highways: North Ridge (Detroit Avenue), Middle Ridge (Center Ridge Road), Butternut Ridge (Lorain Avenue). Associated with the main beach lines are also numerous smaller sandy ridges and some peat and muck deposits. Swampy areas were formerly numerous here.

Within the county this portion of the Lake Plain is cut by the valley of Rocky River, including small portions of its East and West Branches, and also by numerous smaller streams emptying directly into the lake. Of the latter Cahoon Creek is the largest. Abram's Creek, a small tributary of Rocky River, has cut a narrow, steep-walled gorge through the underlying shales as it approaches its juncture with the river.

The valley of Rocky River here is steep-walled, narrow and flat-bottomed, being cut through the soft underlying shales since the last glacial period. Its old filled-in valley, about a mile in width, crosses this part of the plain, adding a further character to the soils of the region (see Fig. 2).

5. *The Till Plain* — The till plain portion of the county is that relatively small area lying in its southwesterly corner, which, during the last glacial period, escaped being covered by the waters of the glacial lakes (see Fig. 1). As a consequence, its soils have none of the sands and silts such as were deposited by the old lakes whose beaches in this region reached only as far south as North Olmsted. The land of the Till Plain is quite flat, poorly drained, and the soil is largely or entirely of glacial till. Like the land of the adjoining Lake Plain, it contained many wet and swampy spots, a famous one being the so-called Abram's Lake. Abram's Lake itself has now almost entirely disappeared, but its outlines can be traced within the boundaries of a considerable area of peat and muck deposits. Its location is at the base of the escarpment, extending in a north-south direction within the old filled-in valley of Rocky River. It is somewhat less than a mile wide, and including the old "Podunk Swamp" to the north, about

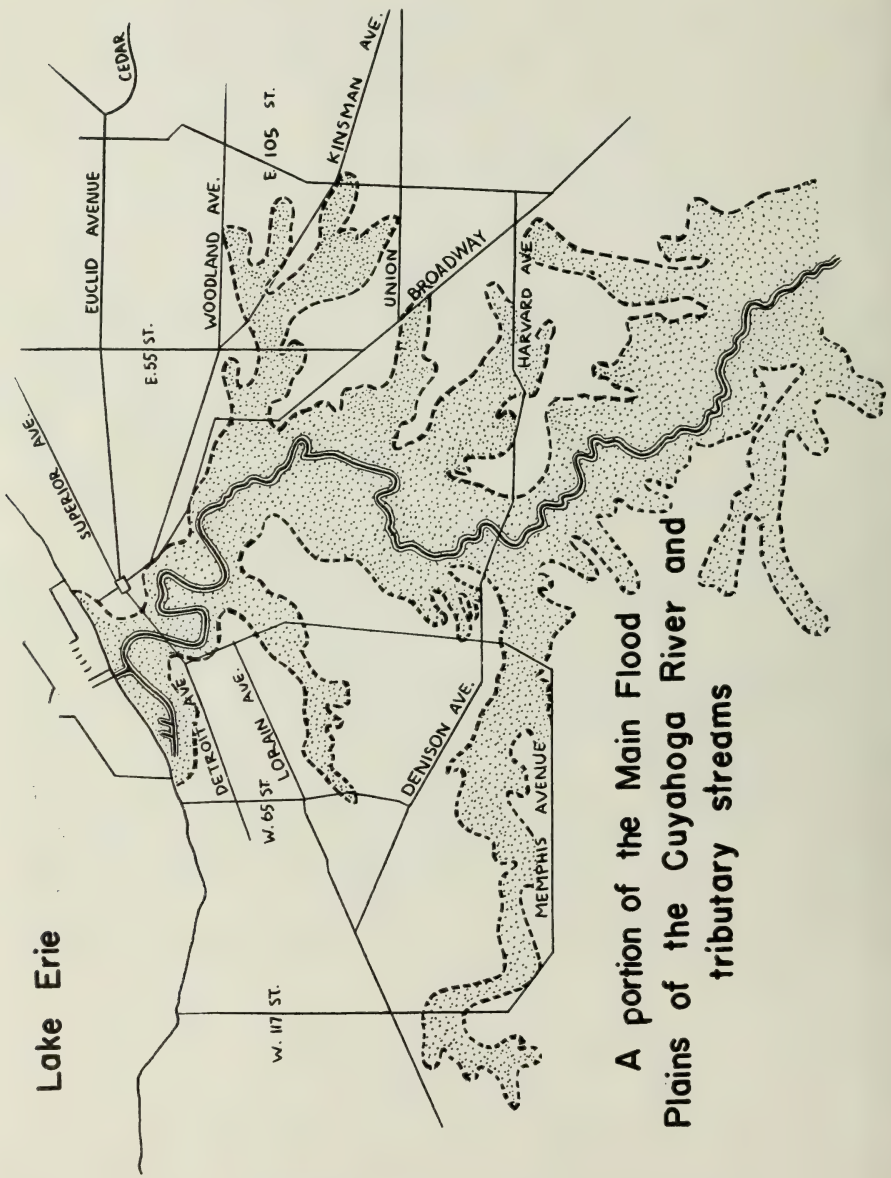

FIG. 3. Flood Plains of the Cuyahoga River and tributaries.

3 miles long. It is now largely enclosed within the area bounded by Bagley, Engle, Five Points, and Eastland Roads. The open water of years ago lay between Bagley and Sheldon Roads, the swampy lands reaching northerly to include the eastern edge of the present Cleveland Airport. This was the place to which Oliver Hazard Perry drove for his deer hunts in 1840 (Hunting Expeditions of Oliver Hazard Perry, of Cleveland, 1899), and was formerly a favorite Indian hunting ground. It is now traversed by the various small streams that finally come together to form Abram's Creek.

FIG. 4. Flood Plain of the Cuyahoga near Fitzwater Road.

6. *Flood Plains* — The main streams of the county have already been noted, and something of their character as they affect topography and drainage pointed out. It remains only to indicate that in connection with some of them, flood plains of considerable acreage were developed. Chief among these are the flood plains of Rocky River and the Cuyahoga, and some of their tributaries (see Figs. 3 and 4). These flat, river-bottom lands, built up gradually by stream action, consist of fine deep soils composed of deposits of transported clays, sands, loams, and finely divided shale particles, enriched by the nutrients leached out of the soils of the surrounding

countryside. Measurements made by the writer in the Rocky River Valley midway between the confluence of the two branches and the lake shore, show this soil to be fully 10 feet deep at this point. In the valley of the Cuyahoga particularly, broad flood plains have developed which have furnished some of the most fertile farming lands of the county. (see Fig. 4).

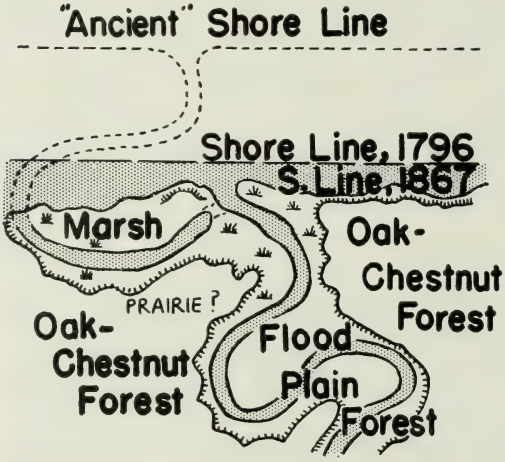

FIG. 5. Mouth of the Cuyahoga River, adapted from maps published in the First Geological Survey of Ohio (1858) and Early History of Ohio (Whittlesey 1867).

7. *Ponds, Lakes, Marshes* — With the exception of "Abram's Lake" (see p. 13) there are no ponds or lakes of any consequence within the limits of the county. In a few places evidences of former beaver dams still persist. One of the best of these at the present writing is in Lake View Cemetery near the Wade Memorial Chapel. Marshes of any great extent are also absent. Most of those which existed formerly were associated with the meanders of the lower portion of the Cuyahoga River. There was also a considerable area of marsh on the west side of the mouth of the Cuyahoga (see Fig. 5).

8. *Lake Erie Beaches* — Probably no part of the Lake Erie shore line of 1796 within the county now remains (see Fig. 5). In the early days of Cleveland's history, erosion of the shore line was rapid and continuous, and was a cause of concern to the early settlers (Mather, 1838). From 1796 to 1842 it was reported that 218 feet along the city front had been lost by erosion (Howe, 1890). At the mouths of some of the streams a limited sand dune area was probably present in 1796. This probably would have been true of Euclid Creek, Ninemile Creek, Doan Brook, Cuyahoga River, Rocky River, and Cahoon Creek. These then, as now, were no doubt subject to frequent shifting by lake currents and wave action. Aside from these few areas, the waves of the lake washed the base of the cliff, or came so close to it that little foothold was offered for vegetation (Mather, 1838).

III.

CLIMATE

Just as physiographically the State of Ohio presents a transition from plateaus to plains, so its climate is transitional between that of the Atlantic seaboard and that of the interior lowlands (Peattie, 1923). Cuyahoga County, lying astride the Portage Escarpment and bordering on Lake Erie, reflects this transition character of climate sometimes in spectacular ways.

The average annual mean temperature, as reported by the U. S. Weather Bureau at Cleveland for the 75 years of its operation, is 48.5 degrees F. Extremes rarely have fallen below a few degrees below zero F., or have risen higher than 100 degrees F. Annual precipitation has averaged 33.8 inches of water, and this is usually well distributed throughout the year.

These figures, however, do not accurately reflect the climatic conditions throughout the entire county, nor would it be possible for records obtained at any one station to do this. (Wolfe, 1945).

Along the Lake Erie shore the climate is greatly modified by the presence of the lake. As has often been pointed out, temperatures near the lake do not rise so high nor fall so low as they do farther inland. This makes possible a growing season (time between last killing frost of spring and first killing frost of autumn) on the lake plain of 200 days. On both eastern and southern highlands extremes of temperature show a wider range.

The presence of Lake Erie is also responsible for a condition of cloudiness that cuts down very appreciably the amount of possible sunshine (Moseley, 1897). During the year this may amount to a reduction of as much as 52 per cent of the possible hours of sunshine.

Records of precipitation taken at the United States Weather Bureau station in downtown Cleveland where it was located prior to 1941, were often astonishingly different from those obtained on the plateau to the east. This condition first came forcibly to the writer's attention when he was studying intensively a portion of the forest in the North Chagrin Reservation of the Cleveland Metropolitan Park System, located on the eastern highlands near the eastern boundary of the county.

For the four years 1932 to 1935 inclusive, weekly records of rainfall as well as other climatic records were secured at North Chagrin. It was soon noted that these were often quite different from those reported by the U. S. Weather Bureau at Cleveland. This was remarkably so in 1934 — the year of extreme drought in the western United States. For that year the Cleve-

land Weather Bureau records showed a total precipitation of only 22.8 inches. At North Chagrin, approximately only 15 miles to the east, the instruments recorded a total of 39.2 inches for the same period — an excess of 16.4 inches over the Cleveland records. (Williams, 1936).

At the Holden Arboretum, located on the plateau six miles to the northeast of North Chagrin, for the month of June, 1940, the rain gauges showed a good 8 inches of water, as compared with 3.5 inches recorded by the Cleveland Weather Bureau for the same period.

The explanation of these differences is no doubt that the prevailing westerly winds, blowing across Lake Erie, tend to accumulate moisture which is not precipitated until the plateau is reached. Here the moisture-laden air is deflected upwards, becomes suddenly cooled, and precipitation follows.

The fact that the shore line of the lake changes at the mouth of the Cuyahoga River from an east and west, to a northeastly-southwesterly direction, makes the region northeast and east of Cleveland (eastern highlands) particularly subject to rains which often completely miss the lake plain and southern highlands. While no definite figures are available for the eastern and southern highlands as such, anyone who is accustomed to observe local weather conditions will probably sense the fact that rainfall definitely increases easterly, so that it is quite probable that precipitation is less on the southern highlands than on the eastern highlands.

IV.

METHODS EMPLOYED IN THIS STUDY

1. The Problem

In our day it is almost impossible for the average city dweller to visualize the density and character of the forest that once covered the land within the boundaries of Cuyahoga County. This is so not only because very few remnants of original vegetation now remain here, but also because very few such remnants are to be found anywhere else in the eastern part of the United States. It has frequently been emphasized that no other part of North America has been so profoundly altered by the works of man as has this section of the continent, and Cuyahoga County, in the State of Ohio, is no exception to this fact.

Mr. Charles K. Arter, in a letter to the writer, says, "My father was born in Tuscarawas County in 1841. I have heard him tell that when he was a small boy and had to drive from his home to certain other farms, how he was terrified at times by the thickness and darkness of the woods and forest that stood like a wall right up to each edge of the road."

FIG. 6. Measuring the largest cottonwood with steel diameter tape. The tree stands on the west bank of Rocky River just south of the Puritas Springs Road Bridge. It measures 5 feet 3 inches dbh. *Photo by Clayton Knipper, Cleveland Press.*

Cuyahoga County's nearby forests, no doubt, presented a similar picture when the first roads were being surveyed. We must not, however, think of this forest as being composed entirely of giant trees. Although there were many big ones, there was much younger growth as well, and frequently places where secondary succession due to windfalls was in progress. Twenty to thirty huge specimens per acre is the estimate of the Ohio Agricultural Experiment Station. (Forestry Publication, No. 76, 1944).

At the present time the City of Cleveland, built solidly in the northern-central part of the county, occupies about one sixth of the 453 square miles of the county's area. Metropolitan Cleveland, with its widespread and varied industries; its massive business section; its outlying community centers; has completely wiped out, within its limits, except for a few parks and outlying private estates, all evidence of the forest that formerly occupied its site. Even in the residential sections, both of the city and its suburbs, the land was once completely cleared for farms and practically no traces of original vegetation remain.

Cuyahoga County is now so completely occupied by cities and villages that out of its 59 political subdivisions, only 3 retain their township status. In other words, the problem with which we have to deal in this study is almost entirely one of changes brought about by man, rather than those due to natural causes.

In a situation such as the foregoing, the difficulty of reconstructing the picture of the forest of the past is not to be minimized, but it is not insuperable.

2. METHODS

In this study the following methods were employed:

(1) Systematic coverage of the county by automobile and on foot to locate and study all possible remnants of the original forest, including single large isolated trees. On these trips a map of the county was always carried, and notes made thereon showing:

a. Areas where portions of apparently original forest still remain, and the probable character of the forest of which they were once a part.

b. The location and species of individual isolated trees, large enough to be over 150 years of age. The largest of these were measured with steel diameter tape for dbh*. (see Fig. 6).

c. The location and character of more recent forest stands, where these seem to have value as indicating the character of former vegetation on these areas.

*Diameter breast high.

d. The character of topography and drainage, where these conditions seem to be important to an understanding of former forest conditions in such locations.

This work was facilitated greatly by the fact that for the last 18 years the writer, in his capacity of naturalist and ecologist for the Cleveland Metropolitan Park Board, and Curator of Education for the Cleveland Museum of Natural History, has had occasion to visit constantly, in the course of his work, all parts of the Cleveland Metropolitan Park System. These park lands lie in a great semicircle of reservations surrounding the City of Cleveland in the outlying parts of the county. Fortunately, within these reservations are to be found some of the best remnants of original forests, and it has been the writer's privilege to study these in detail and unhurriedly.

A mass of notes relative to forest conditions both within and without the park system has thus been accumulated. With a little extra effort every nook and corner of the county that might produce evidence germaine to this study has now been personally explored by the writer.

The writer's service as chairman of the Advisory Committee for the Survey of Cleveland City Street Trees, completed by the WPA in 1939, and as chairman of the Cleveland Sesquicentennial Commission's Committee on Moses Cleaveland Trees in 1946 gave him some familiarity with the occurrence of the few large native trees still standing on Cleveland's city streets, as well as elsewhere throughout the county.

In addition, through radio broadcasts and newspaper publicity, reports of the location of some 280 large isolated trees were secured, and most of these which seemed important were investigated.

(2) Visitation and study of forested areas outside of, but contiguous to the eastern, western and southern limits of the county, as well as other areas nearby, which contain remnants of original vegetation such as probably formerly existed within Cuyahoga County.

(3) Use of intensive ecological studies, made by the writer, of areas within the Cleveland Metropolitan Park System, and at the Holden Arboretum in Lake County, which is contiguous to Cuyahoga County on the east. The composition and dynamics of local beech-maple, flood-plain, and oak-hickory communities, and the course of secondary succession within and adjacent to a beech-maple-hemlock community, have thus been studied in detail.

(4) Examination of early accounts of the settlement of Cleveland and the Western Reserve, early newspapers, original road surveys, old photographs, maps, and other early documents that might contain references to

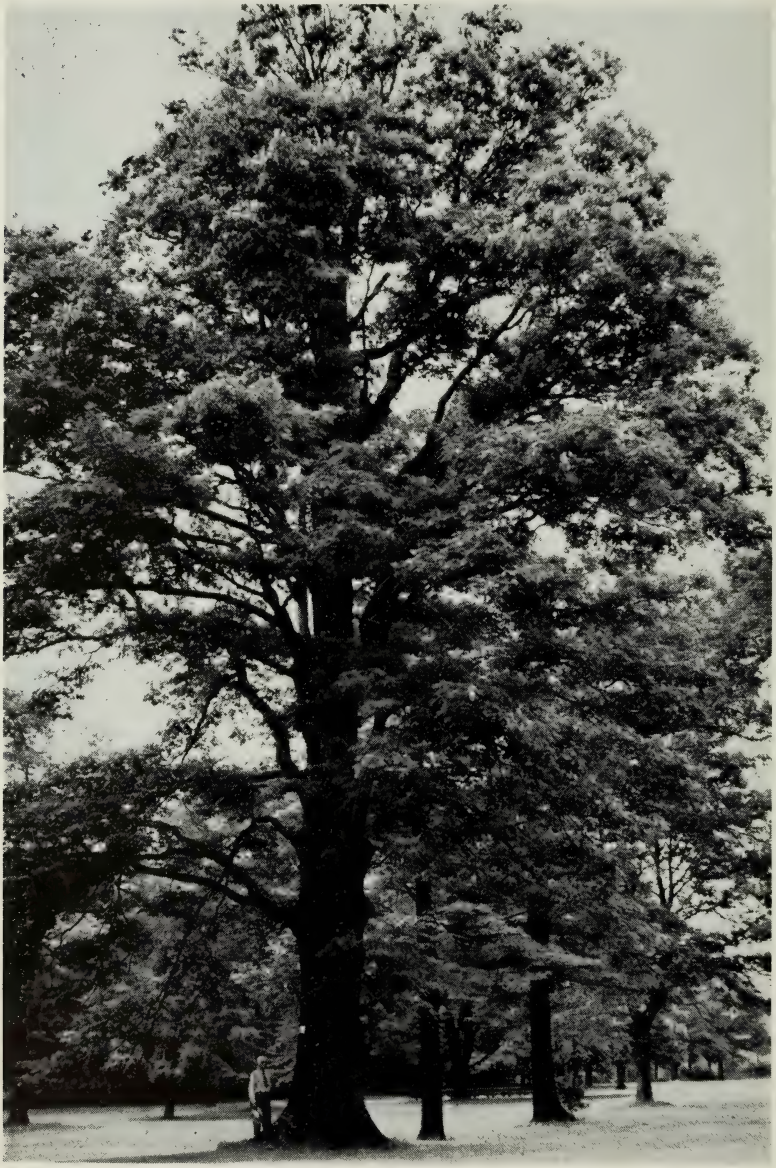

FIG. 7. The largest white oak. It stands in Forest Hill Park, the former estate of John D. Rockefeller. It measures 4 feet 8 inches dbh. *Photo by Dudley Brumbaugh, Cleveland Plain Dealer.*

the character of the original forest. The Cleveland Public Library, the libraries of Western Reserve University, of the Western Reserve Historical Society, and of the Cleveland Museum of Natural History, as well as the records of the Cuyahoga County Engineer's Office, have all yielded material.

(5) Interviews with persons who either have lived many years in the county, and whose memories may be relied upon to give an accurate picture of former conditions, or whose family tradition contains such information. Especially important are the statements of old lumbermen who recall vividly the character of the local forests in which they worked 40 or 50 years ago.

(6) A theoretical reconstruction of the original forest on the basis of topography, drainage, climate and soils, in the light of the writer's familiarity with the distribution and composition of the present forest communities of the region.

(7) A final combination of all of the information obtained through the methods above outlined into a single map, showing with as much detail as possible the probable composition and distribution of the forest communities present in the county in 1796.

In making a final interpretation of the facts found, certain ecological assumptions were adopted as guiding principles. The chief of these were the following:

1. Forest remnants that have evidently been subjected to little disturbance, containing trees of size sufficient to indicate an age of 150 years or more, are assumed to be representative of the character of the original forest on these, and similar nearby locations. These are the "climatic relicts" of Clements, who uses the term "with equal warrant" as applied either to a community, a species, or an individual tree. In either case "it is practically a universal rule that a community of some degree is concerned". (Clements, 1934).

In other words, even individual isolated trees of apparent age sufficient to identify them as a part of the forest of 150 years ago have an indicator value as components of a former forest community, the character of which may be closely inferred from the known ecological relationships of such species.

2. Most present native forest growth, even though comparatively recent, also has an indicator value with reference to the type of vegetation formerly occupying the same site. Of course, following the clearing of the

original forest, a forest of secondary succession character developed. Many remnants of such forests are to be found in the region, and may, with due care, be interpreted in terms of the original forests which they have replaced.

3. Topography, drainage, and the character of the soil all furnish a good criterion for the theoretical allocation of certain forest communities known to be dependent for their occurrence in this climate more or less on such edaphic factors. Physiographic distribution of forest types as they occur at the present time, within the limitations noted below, is a reliable guide to the probable distribution of such types in the past. "The basic relation is that of the species to its habitat" (Clements, 1934).

4. In allocating such probable situations for forest communities of the past, account must be taken of the changes which in the last 150 years have altered both the character of the land and the climate of the region. Thus, the filling in of marshy places, the draining of swamps, the diversion of woodland brooks to storm sewers, and the loss of forest humus which acted like a sponge to conserve moisture, have all combined to produce a much more xeric situation now than was the case before the white man arrived with his axe and plow.

Likewise, the removal of the forest itself has produced profound changes in the local climate. Underneath the dense canopy of foliage forming the practically continuous forest roof of 1796, temperature was lowered, the evaporation rate was cut down through the elimination of direct sunshine and the nullification of the drying-out effects of wind, relative humidity was raised, and the water from rains and snows was trapped and held in the tangle of rootlets of trees and lesser plants of the forest floor. With the removal of this forest cover the local climate has become much drier.

Account must also be taken of the progress of biotic succession in such situations as have retained their forest character to any degree. Thus, species of more northern affiliations, like white pine, hemlock, yellow birch, and black ash, which have long been in progress of displacement here by the climatic climax forest, must be assigned a larger place in the forest of the past than is evidenced by their present relative position.

5. The present-day list of native species, with few exceptions, will furnish quite accurately the list of species-components of the forests of 150 years ago.

FIG. 8 The largest sugar maple. It stands on Butternut Ridge Road beside a little cemetery in North Olmsted. It measures 4 feet 3 inches dbh. *Photo by A. C. Poore.*

V.

THE NATIVE FORESTS OF CUYAHOGA COUNTY

1. The Forests of the Colder Climates

Studies of the stratified deposits contained within a filled-in post-glacial bog near Bucyrus, Ohio, just north of the Ohio-Erie watershed, have revealed in some detail the character of the forests which occupied parts of northern Ohio after the retreat of the glacial ice some 25,000 years ago. (Sears, 1930).

According to the analysis of the stratified pollen deposits obtained from this bog, the progress of forest succession in this region following the withdrawal of the ice sheet, according to Dr. Sears, seems to have been somewhat as follows:

(1) A period during which firs and spruces were the dominant species. This boreal type of evergreen forest is typified by the present-day forests of northern Labrador.

(2) A period characterized by the presence of spruces and pines, a forest type such as is now found in southern Manitoba.

(3) A period when a forest dominated by pines and oaks appeared, a forest type such as may be found in northern Michigan at the present time.

(4) A period during which oaks and a mixed deciduous forest, the forerunner of our present-day northern Ohio forests, appeared.

During each of these periods, the type of forest present probably reflected conditions of climate, such as are suggested by the present-day locations of such forest types, as noted above.

Although no human eye beheld them, forests such as these occurred in Cuyahoga County, and the evidence and the order of their appearance has been accurately preserved in such bog deposits as those cited above.

Another interesting witness as to the presence of such forests is contained in the great mastodon skeleton which stands in the main exhibition building of the Cleveland Museum of Natural History. This itself is a post-glacial bog relic, having been recovered from such a bog near Johnstown, Ohio, where the animal probably became mired some 30,000 years ago. Like all of the elephant group, the mastodon was a feeder upon plants. In the chinks between some of the great molar teeth of this particular animal, wads of spruce gum have been found.

FIG. 9. A picturesque sycamore in Rocky River Metropolitan Park near the Lagoon Picnic Grounds. *Photo by Clayton Knipper, Cleveland Press.*

Of these ancient evergreen forests the few native white pines and hemlocks now found within the county are the only living remnants. As the climate gradually grew warmer following the melting back of the glacial ice front, the boreal type of forest found itself unable to compete with the more efficient broad-leaved trees, and shortly the day of the deciduous forest had arrived. This displacement of the evergreens by the deciduous trees is still in process, though now almost complete.

2. THE FORESTS OF MOSES CLEAVELAND'S DAY

Early accounts of the settlement of Cleveland are disappointingly meager in details regarding the character of the forest encountered by the early settlers. Those hardy pioneers seem to have been little interested in the forest as such, no doubt thinking of it largely as just so much encumbrance to be cleared away before they could begin to realize their dreams of comfortable living.

When Moses Cleaveland and his party arrived at the mouth of the Cuyahoga River, we are told that because of the densely wooded and swampy character of the shores, they were forced to go some distance up-

stream before they could find a landing place. Here, after climbing a "clay bank" some "30 to 40 feet high", the party must have found themselves in a dense forest pressing down on every side to the river margin. Later, Moses Cleaveland described this forest, as it appeared after they had ascended the bank, as "the land level, covered with Chestnut, Oak, Walnut, Ash, and some sugar Maple. There are but few Hemlocks, and those only on a mergin of Swamp, pond or Lake." (Cleaveland, 1796). These are all trees common to the Cleveland region today, and they suggest something of the character of the forest on the east bank of the Cuyahoga near its mouth in 1796. As the first survey included only about one square mile of this forest, it is apparent that the above report is a very limited one.

Today there are probably no places in Cuyahoga County that look as they did in 1796, though only 152 years have intervened. Some trees of that original forest are indeed standing in the same places where they then grew (see Figs. 7,8,9), but the great forests of which they were a part, and the big trees that gave the forests character, have passed away forever.

Yet occasionally one may find small remnants of woodland where the suggestion of the aspect of the original forest still lingers. One may sense something of the look and feeling of it in the beech and sugar maple woods in the North Chagrin Metropolitan Park, or in certain small stands of similar forest overlooking the Chagrin Valley where conspicuous evidences of human occupation have not as yet developed. Here is the high, closed, humid forest of beech and maple, with its small array of regularly associated species, which still is, as it was in 1796, the climax forest of the region. Here one may stand and conjure up in imagination the immense stretches of the "dark beech woods of the Connecticut Western Reserve" (Kirtland, 1838) that formerly shut out the sunlight from the land; that sheltered deer and wild turkeys in abundance in its dark, cool depths; that was famous for its wildcats and wolves; that was rarely disturbed by the presence of a human form. (see Fig. 10).

Or, in the lower part of the gorge of Abram's Creek — a place which at the time of this writing is still largely unspoiled by paths, bridges, roads or other artificial scars — one may find a lingering suggestion of the cold northern type of vegetation in which hemlock and yellow birch play such a conspicuous part, and which sounded the dominant note in the aspect of the gorges and ravines of the region when the first settlers looked upon them. (see Fig. 21).

The Cuyahoga River at Willow, before the beginning of the extensive highway improvements in 1938, presented a picture in which an Indian canoe might be imagined as being entirely in keeping with the surroundings. Here the river was almost entirely closed in from overhead by huge leaning cottonwoods, sycamores, and silver maples, from which dense curtains of

FIG. 10. Beech-maple climax forest, North Chagrin Metropolitan Park.

the river grape hung in sweeping festoons. Farther back from the river's edge were large elms, black walnuts and Ohio buckeyes. (See Fig. 11).

Of the oak and chestnut forests which claimed so large a place in what is now downtown Cleveland, little remains to suggest their former grandeur. Practically nowhere within the limits of the county does there now exist more than a few oaks of forest form and proportions to suggest the former lordly trees of these forests. In Clague Park, Village of Westlake, the remnants of such an oak forest may be seen. A few years ago one might have seen in Lake County on the east (Madison), or in Lorain County on the southwest (New London), examples of the giants of the oak forests of former days. In these places prior to 1941 a few oaks remained towering above the newer forest trees, exhibiting the stately proportions to which the oaks of Cuyahoga County must once also have attained. Some of the largest of these trees must have been growing where they then stood when Columbus first reached the Atlantic seaboard.

A major change which has taken place in our day is the complete disappearance of the chestnut from the native forest scene. The "chestnut blight" (*Endothia parasitica*) appeared first in Cuyahoga County about 1920, and within 10 years most of the big chestnuts were dead. At the time of this writing there are still a few living sprouts about old chestnut stumps, and occasionally one finds a small seedling tree, but the blight is still active and these soon succumb. (see Fig. 12).

Although the forests of former days are gone, it is possible to attempt a reconstruction in some detail of the picture of the forest cover of Cuyahoga County as it appeared in 1796. In doing this it will be both convenient and useful to follow the various topographic features of the land as outlined under Section II (pp. 7-16).

Scientific and common names of trees used herein are, with a few exceptions, in accordance with those in *Trees of the Eastern United States and Canada*, by William M. Harlow (1943). For complete species list with both common and scientific names see pages 68-88.

1. *The Eastern Highlands* — In this section of the county (see Fig. 1) during the time of this study there existed more fragments of native forest character than in any other part of the region. Among the best of these are four Metropolitan Park Reservations — Euclid Creek (338 acres), North Chagrin (1497 acres), South Chagrin (509 acres), Bedford (1203 acres). (Board of Park Commissioners, 1947). In these reservations are some of the finest relics of original natural vegetation to be found in the entire county. All have been studied in detail by the writer, one such study having been published under the title "The Composition and Dynamics of a Beech-Maple Climax Community". (Ecological Monographs, 6:317-408; and Scientific Series, Vol. VI, Cleveland Museum of Natural History).

FIG. 11. Cuyahoga River near Tinker's Creek Road. An Indian canoe would not seem out of place here. Silver maples and elms along river edge.

Other smaller fragments of original forest character are scattered over the entire area, but are more numerous easterly. These are made up almost exclusively of beech and sugar maple with associated species characteristic of the beech-maple climax forest of the region. A few consist of remnants of elm-ash-red maple communities so characteristic of the more wet and poorly drained areas of the locality. In the southwestern part of the eastern highlands, remnants suggesting former oak-hickory and oak-chestnut communities become quite pronounced.

The distribution and character of all these remnants are such as to indicate clearly that the eastern highlands was a region formerly almost entirely occupied by a climax forest of beech and sugar maple, with certain variations in the form of inclusions due to topography and drainage.

A. *The beech-maple climax* — A typical piece (65 acres) of beech-maple climax forest of the approximate age of 250 years is described in detail in the writer's study previously alluded to (Williams, 1936). In this area it was found that in numbers of trees of $3\frac{1}{2}$ inches in diameter or over, beech made up 52.6 per cent, sugar maple 32.7 per cent. It is quite probable that 150 years ago beech held an even more commanding place in the climax forest of the region. The frequency with which beech is noted in the county by early writers, to the exclusion of other species, points to this conclusion.

as well as the fact that in the forest remnants above referred to, large old beech trees are more common than large old sugar maple trees. It also appears that in the process of displacement of hemlock by the deciduous forest due to biotic succession, which has been going on for a very long time, the order of succession seems to have been beech before sugar maple. (Williams, 1936). (see Figs. 13, 14).

In close association with beech and sugar maple in the climax forest, red maple, tulip, white ash, cucumber and tupelo occur; and there are enough old trees of these species still extant to assign them a definite place as secondary dominants in the original forest of the region. The present common understory trees — hophornbeam, flowering dogwood and shadbush — no doubt occupied much the same position then as now. This would be true also of the characteristic shrubs of the present forest, namely: witchhazel (*Hamamelis virginiana*), spicebush (*Benzoin aestivale*), maple-leaved viburnum (*Viburnum acerifolium*), red-berried elder (*Sambucus racemosa*), and purple-flowering raspberry (*Rubus odoratus*). There is a rich herbaceous growth of early spring "wildflowers", of which the most characteristic are hepatica (*Hepatica acutiloba*), spring beauty (*Claytonia virginica*), and great white trillium (*Trillium grandiflorum*).

B. Where swampy and poorly drained areas occurred, there would be found within the beech-maple climax smaller areas of the characteristic upland swamp forest in which American elm, black ash, and red maple were the dominants, and swamp white oak, basswood, and bitternut hickory commonly also occurred. Where streams developed enough width to let in the sunlight, black willow, heart-leaved willow and pussy willow would be found. In many such a place, now entirely cleared of forest, large isolated American elms often appear to mark the spot where in former years some small area of swamp forest once held sway. American hornbeam, spicebush and poison ivy (*Rhus radicans*) are now, and undoubtedly were formerly the common understory plants of this hydrarch association. (see Fig. 15).

C. The slopes of the Chagrin Valley walls, when not too steep, were occupied by hemlocks, and here we must assign to the hemlocks much more territory than they now occupy. Their dead remains, reaching back into the present deciduous forest, and the progress of climatic succession set forth previously (p. 24) warrant the assumption that hemlock 152 years ago was a much larger component of the forest than is now the case. In this tension zone between beech-maple and hemlock, frequently extensive beech-hemlock associations were present. This was also the place where oaks (red oak, white oak, scarlet oak) and chestnut occurred. Here also were the hickories, especially pignut and shagbark. It is also the place where occasional white pines still persist. American yew (*Taxus canadensis*), leatherwood (*Dirca palustris*), fly honeysuckle (*Lonicera canadensis*), and bush honeysuckle (*Diervilla lonicera*) are the characteristic shrubs, and

FIG. 12. Chestnut formerly standing near escarpment edge overlooking Chagrin Valley.

Canada mayflower (*Maianthemum canadense*) the characteristic herbaceous plant. (see Fig. 19).

D. In the southwestern portion of these eastern highlands, as the Cuyahoga Valley is approached, oaks and remains of chestnut become more numerous. Fine examples of large white oak, black oak, scarlet oak, and red oak are to be found on the ridges and at the tops of the slopes. Here also tulip and remains of chestnut appear frequently. As one descends the terraced valley slope these species become more common. These species are also characteristic of the opposite slope of the valley wall to the west, as was noted by Wolcott in 1811 (see p. 35), and we assume that here on the ridges extending down into the Cuyahoga Valley, a forest dominated by oak and chestnut, with white ash and shagbark hickory, occurred. Beech, sugar maple, tulip, white ash and basswood claimed the slopes between the ridges. In Garfield Park at the present time are a few remnants, indicating a beech-maple forest mixed with white oak as having once been present here.

2. *The Southern Highlands* — In this part of the county is situated the Brecksville Reservation of the Metropolitan Park System (1784 acres), and the narrow strip of parkway connecting the Brecksville and the Rocky River Reservation (265 acres). Within this section also occur portions of the Rocky River Reservation lying along the East Branch of the River (2381 acres). The Hinckley Reservation (1154 acres) lies immediately south of the Cuyahoga County line in Medina County, and its type of vegetation should reflect accurately that of the former forests of the contiguous areas of Cuyahoga County. The forests of these reservations have been studied in detail by the writer.

Most fortunately, a written account of the character of the native forests of the Township of Brecksville (25 square miles), which includes the entire slope from the highest portion of the southern highlands to the flood plain of the Cuyahoga, has been preserved in the "Field Book" of Alfred Wolcott, who surveyed the Township in 1811 for the purpose of dividing it into lots for partition among the owners.

The surveyor made 101 lots, of which about 60 per cent averaged approximately 200 acres each, and about 40 per cent approximately 100 acres each. The four corners of each of these lots are indicated in the surveyor's notes either by trees which he found growing there at the time, or by posts located with reference to living trees. In every case the species of tree or postwood is noted. In addition to this, the surveyor indicates the prevailing type of timber on each lot. In all, 27 species of trees are thus named, and from this record it becomes possible to reconstruct quite accurately a picture of the original native forest of Brecksville Township before it had been in the least altered by the presence of white men.

The following 20 species are mentioned by Wolcott either as living trees at lot corners, posts, or trees from which posts were located. The list is here arranged in order of frequency in which the species is mentioned, the figure preceding the species name being the number of times mentioned. The names are as given in the surveyor's notes, the writer's interpretation of some of these following in parenthesis:

33 White Oak
30 Beach (Beech)
29 Sugartree (Sugar Maple)
18 Ironwood (Hophornbeam)
16 Dogwood (Flowering Dogwood)
14 White Ash
12 Buttonball (Sycamore)
9 Elm (American Elm)
7 Hk. (Shagbark Hickory)
6 Poplar (Cottonwood)
6 Buck Eye (Ohio Buckeye)
5 Black Oak (Black Oak and Red Oak)
5 Chestnut
3 Willow (Black Willow)
2 Maple (Red Maple)
2 Blew Beach (American Hornbeam)
1 Butternut
1 Sassafras
1 Black Ash
1 Box Elder (Ash-leaved Maple)

The following 7 species (thus making 27 in all) are named as additional "timber" trees found on the lots: White Pine, Hemlock, Cucumber, Black Walnut, Plumb (Wild Plum), Crabb Tree (Wild Crab), Bass. (Basswood).

By marking on the map the species of tree indicated for the corner of each lot, and noting thereon the predominant timber trees for each lot as indicated by the surveyor, a rather complete picture of the original forest of Brecksville Township is constructed. The species most frequently mentioned is "White Oak"; and "Oak, Hk, Ash" is the most frequent designation for timber trees on lots. The next most frequently mentioned species is "Beach", with "Sugartree" a close third. Using the frequencies noted in the list above, it appears that a little less than 50 per cent of the forest surveyed may have consisted of white oak, beech and sugar maple in nearly equal proportions.

From these records it is also apparent that beech and sugar maple were best represented in the southwestern part of the Township, which lay on the higher, more level, lands; and that oak, hickory, and chestnut dominated the ridges of the rest of the western section of the Township, with some admixture of beech and sugar maple. From the middle of the Township eastward, except on the bottomlands of the Cuyahoga, oak and hickory predominated almost to the exclusion of beech and sugar maple.

In connection with lot 23 the surveyor says, "near Chipua Creek is a considerable grove of White Pine Timber." In connection with lot 32, which adjoins lot 23 on the south, he says, "on the north side of Chipua Creek is some very good White Pine Timber." This is along the present Royalton-Northfield Road and not far from the Metropolitan Park entrance near the head of Chippewa Creek gorge.

FIG. 13. Beech among hemlocks. North Chagrin in summer.

FIG. 14. Sugar maple. North Chagrin in winter.

In connection with lot 64 (near the present northeastern corner of Boston and Broadview Roads), the surveyor notes "at the N. E. corner is a Black Ash Swamp", and significantly, this corner is marked with a black ash post, located with reference to a nearby black ash tree. Apparently there was a considerable area of poorly drained flat upland country in this region. It is near here that Mr. Don Knowlton recalls an extensive "hickory swamp".

It is of special interest to note that into this picture from Alfred Wolcott's surveyor's notes the present vegetation of the Brecksville Reservation of the Cleveland Metropolitan Park System fits perfectly, except that the chestnuts are gone and no traces of the white pines remain.

On the Lister place, on Snowville Road, grow several large white pines, apparently at least 100 years old, said to have been transplanted as seedlings from the surrounding neighborhood, that could well have come from the stand described by the surveyor.

Wolcott also mentions hemlock a number of times. There are still hemlocks in Chippewa Creek gorge. Mr. Don Knowlton recalls the lower gorge of Chippewa Creek when it was "solid hemlock arching over the stream so that the tops of the trees interlocked." (see frontispiece).

Aside from the very considerable forest remnant on the steep slope between Ridge Road and York Road (which is largely beech and maple, with the usual associated species), and that included in the Brecksville Reservation noted above, the remaining evidences of native forests in the southern highlands are not nearly so numerous as in the eastern highlands section. Enough remains, however, to indicate that in this more xeric location (pp. 9,18) the oaks and chestnuts held a more commanding place than did beech and sugar maple, though the latter were present in some abundance. It should be noted that a remarkably fine example of beech-maple climax forest included within the limits of the Akron Metropolitan Park System (Summit County) still stands on the Brecksville Road just south of the Cuyahoga County line. Charles Willard says that on land adjoining Cuyahoga County to the south in Medina County the forest was of beech and maple. There was once a large "sugar bush" here where the trees were so big "you could hang three buckets on one tree". There was not much chestnut or oak but plenty of "whitewood" (tulip).

The 7 miles of parkway connecting the Brecksville Reservation with the parkway along the east branch of Rocky River traverses a woodland, the species composition of which points strongly to the probability that all of this high land was formerly occupied by a beech-maple climax forest.

The northern front of the southern highlands, however, supported a forest of oak, chestnut, hickory, ash and tulip. In an interview which the

writer had with Mr. John Ord in 1941, this veteran lumberman, who had worked in the forests of this part of the county since boyhood, indicated that throughout the Parma and Brecksville region there was formerly much chestnut, oak (white, red and black), and tulip, and that white oak especially from this locality was much in demand for ship's timbers. There were places here which he remembers as "solid white oak". (see Fig. 20).

Mr. Don Knowlton recalls "chestnut all over the hillsides" along the creek on the south side of Schaaf Road. Between State and Broadview Roads there was "much chestnut, with hemlock overhanging the gorge".

The Wolcott survey notes, the present forest remnants in the park reservations, and the testimony of those whose memory of other days serves to reconstruct the picture of the old forests, all agree in effect that there once existed here on the northerly slope of the escarpment some remarkably fine pure stands of white oak; and that, farther to the south, white oak, black oak, red oak, scarlet oak and chestnut occupied the ridges; while the climax forest of beech and sugar maple, with their characteristic associated species, among which white ash, cucumber and tulip were common, occupied the highlands and the slopes between the ridges. In the ravines and gorges, hemlock, white pine and yellow birch were characteristic species. (see Fig. 21).

In this oak-hickory-chestnut forest the characteristic shrubs of the beech-maple association were largely absent and herbaceous growth was sparse. Partridgeberry (*Mitchella repens*) sometimes produced a considerable ground cover. Trailing arbutus (*Epigaea repens*) and wintergreen (*Gaultheria procumbens*) were not uncommon. The moss *Leucobrym glaucum* was characteristic.

It is worthy of note that the hepatica of the southern highlands is *Hepatica triloba*, as contrasted with *H. acutiloba* of the eastern highlands.

3. *The Escarpment Edge, Ravines and Gorges* — As one approaches the escarpment edge from the eastern highlands it is evident that a pronounced change in the character of the forest occurred at this point. With increased dryness, due to the decreased water-holding capacity of the soil, the beech-maple forest here gave place to oaks and chestnuts. Near the top of the slope, white oak was apparently the most abundant species. Associated with white oak were red oak, scarlet oak, and chestnut oak. Chestnut was an abundant species. Shagbark hickory, pignut hickory and sassafras were also components of this oak-chestnut association. Farther down the slope, as moisture again began to accumulate in the soil, beech and maple once more appeared, and with them, white ash, tulip, cucumber and tupelo.

Some fragments of this oak-chestnut forest are still to be seen on either side of Richmond Road as it descends the slope to Euclid Avenue in the City of Euclid; along the top of the steep slope from Brush Road to Euclid Creek Metropolitan Park; and in Forest Hill Park, East Cleveland.

FIG. 15. American elm, Lander and Wilson's Mill Roads, Mayfield Village. A good example of the "farmhouse elm". It measures 5 feet dbh.

The occurrence of chestnut oak within the county at the present time is restricted to the edge of the escarpment in this northeastern section. At the head of Euclid Creek gorge and in Forest Hill Park it is well represented. It persists as far west as the gorge of Doan Brook, but beyond this point the writer has been able to find it represented by only a single young tree of 6-inch diameter size. This is on the grounds of the Children's Fresh Air Camp overlooking the southerly side of Kingsbury Run, and it may indicate the former presence of the species here in larger size. West of the Cuyahoga River there seem to be no traces of chestnut oak at the present time.

The deep, cool ravines which characterize the escarpment base are even now occasionally dark with hemlocks, which are usually associated with yellow birch, black birch, tulip, basswood, and an occasional beech or red maple. One hundred and fifty years ago these ravines and gorges must have been more fully occupied by vegetation of northern character than is now the case. Here it was, also, that white pine occurred in small stands, and mountain maple, now rare in Cuyahoga County, could be found. (see Fig. 21).

4. *Lake Plain*—For purposes of study it will be convenient to divide the Lake Plain portion of the county into three sections.

A. *Eastern Section* — That portion of the Lake Plain east of Doan Brook presents such a relatively flat surface that in many locations here in times past there must have been large areas of wet, swampy, marshy or poorly drained lands. In this section today, although largely occupied by homes and factories, one encounters individual large trees of pin oak, red oak, swamp white oak, bur oak, American elm, white ash, tulip, and silver maple; with occasional red maple, tupelo, white oak and shagbark hickory. Beech occurs occasionally as a large tree, but more often as a smaller tree, apparently arriving because recent drainage has made the area more mesic in character. Sugar maple is also present in large size where the water table is not too high.

Wherever natural reforestation is in progress the common trees are cottonwood and pin oak. There are numerous stands of relatively young pin oak. There are some remains of chestnut.

It is apparent that pin oak once dominated large areas of this wet, flat country. Associated with it in lesser numbers were swamp white oak, bur oak, silver maple, red maple, tupelo, and occasionally cottonwood. Where the land was slightly higher, and the water table consequently lower, sugar maple replaced silver maple; and beech, tulip, shagbark hickory, and white ash appeared. In very wet places the northern Ohio lowland swamp forest,

dominated by American elm, black ash, and silver maple, held sway. This was particularly true of areas along the line of the Lake Erie shore where the so-called "black forest" of pioneer days was located. There are still some very large American elms and silver maples in this region, though the land is now largely occupied by homes.

On the sandy ridges representing old beach lines, white oak, red oak, black oak, sassafras and chestnut were common species.

The Village of Bratenahl, lying along the Lake Erie shore from the mouth of Doan Brook eastward for over two and a half miles, contains some fine old trees of forest type, and in several places some real, though small, forest remnants. The soil here is largely sandy old lake beach, and upon it still grow some fine large old examples of black oak, scarlet oak, white oak, red oak, white ash and American elm. Chestnut was formerly present in very large size. Mr. B. P. Bole, Jr., remembers a 36-inch pignut and a 60-inch tupelo between the boulevard and the lake shore just east of Gordon Park, which have disappeared only in the last few years.

This part of the lake plain is crossed by numerous short streams, in addition to the larger ones already mentioned. Where these cut through the lake cliff overlooking Lake Erie, short ravines or gullies are formed which may be from 30 to 50 feet deep. In such places today are commonly found American elm, cottonwood, basswood, white ash, beech, sugar maple; and occasionally red maple, tupelo, tulip, cucumber and silver maple.

Apparently, as better drainage is established in these short gullies, the beech-maple climax forest tends to reassert itself. It seems safe to assume that this is no new condition, but that it reflects the type of vegetation common to these gullies in the past.

B. *Central Section* — The portion of the lake plain from Doan Brook west to Edgewater Park, and south to Willow, in the throat of the ancient Cuyahoga delta, is that which is now almost completely occupied by the City of Cleveland. Across it the present Cuyahoga River flows. In this section very few evidences of original forest remain, and it is here that we have our greatest difficulty in attempting an accurate reconstruction of the picture of the forest of 1796.

The valley of Doan Brook, which crosses the lake plain just west of Bratenahl, and which now includes Gordon, Rockefeller, and Wade Parks, still contains a few remnants of original forest. On the slopes are beech, sugar maple, tulip, cucumber, white ash and tupelo. At the top of the bank and on the sandy beach lines are black oak, white oak, red oak, scarlet oak, tulip, and remains of chestnut. The old tulips just north of the Cleveland Museum of Art are real landmarks.

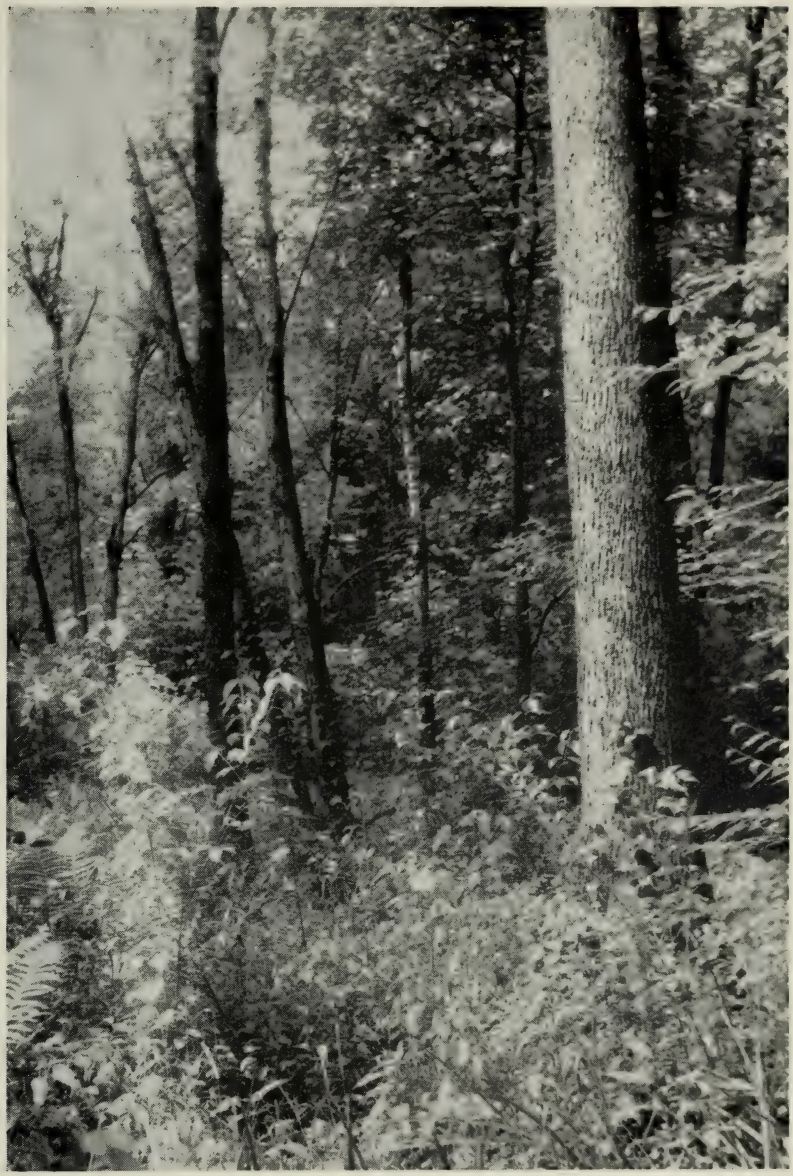

FIG. 16. Swamp forest at northern end of Aurora Pond. Black ash and yellow birch.

Along the line of the old beach of glacial Lake Warren (Cedar, Carnegie and Euclid Avenues; and cross-streets east of East 55th Street), there were at the time of this study a few large old isolated trees of tulip, white oak, black oak and white ash, but these are disappearing rapidly. (see Fig. 18).

In the southern part of this central section of the lake plain, near the sewage disposal plant at Willow, is a considerable remnant of a former beech-maple forest, with a few white oaks and remains of chestnut at the top of the slope. In Washington Park there still remain a few old stag-headed tulips to indicate something of the character of the original forest there.

References in the early surveyors' notes and recollections of people whose memories of early Cleveland go back 60 to 70 years with whom the writer has talked all agree as to the presence, in what is now downtown Cleveland, of numerous wet and swampy places which have since disappeared. One such area was in the vicinity of Euclid Avenue and East 55th Street. Another was at University Circle. Others were along Cedar and Kinsman Roads. The corner of Euclid Avenue and Erie (East Ninth) Street was referred to in 1852 as the "Euclid Frog Pond" (Orth, 1910). Dr. J. P. Kirtland, writing in the *Family Visitor* of July 2, 1851, mentions "an extensive marsh running between Euclid and Kinsman streets" which was later drained and became fine farm land.

Mrs. G. H. Michel remembers a "large frog-pond" between Prospect and Carnegie Avenues from about East 36th Street to East 46th Street. She also remembers going chestnutting in "Wilson's Woods", which reached from East 40th Street to East 55th Street (formerly Wilson Avenue). Here the trees were "oaks, chestnuts and beech".

Mr. H. E. Willard, whose boyhood was spent on a farm near the corner of Euclid Avenue and East 55th Street, recalls the presence of swampy places in the neighborhood and says that toward the north the largest trees were chestnut, red oak and pin oak — also many pepperidge (tupelo) and "scrawny maples" (silver maple). To the south were large butternut and black walnut trees, ironwood and hickories. Also some white oak and cucumber. He says that west of "the heights" there was plenty of beech but very little sugar maple.

Mr. C. H. Excell recalls many large chestnut trees, beech and black walnut between Euclid and Superior Avenues in the neighborhood of East 105th Street.

Mr. Don Knowlton speaks of numerous large tulips scattered about the region of West 14th Street and Clark Avenue, as far as Riverside Cemetery overlooking the Cuyahoga Valley.

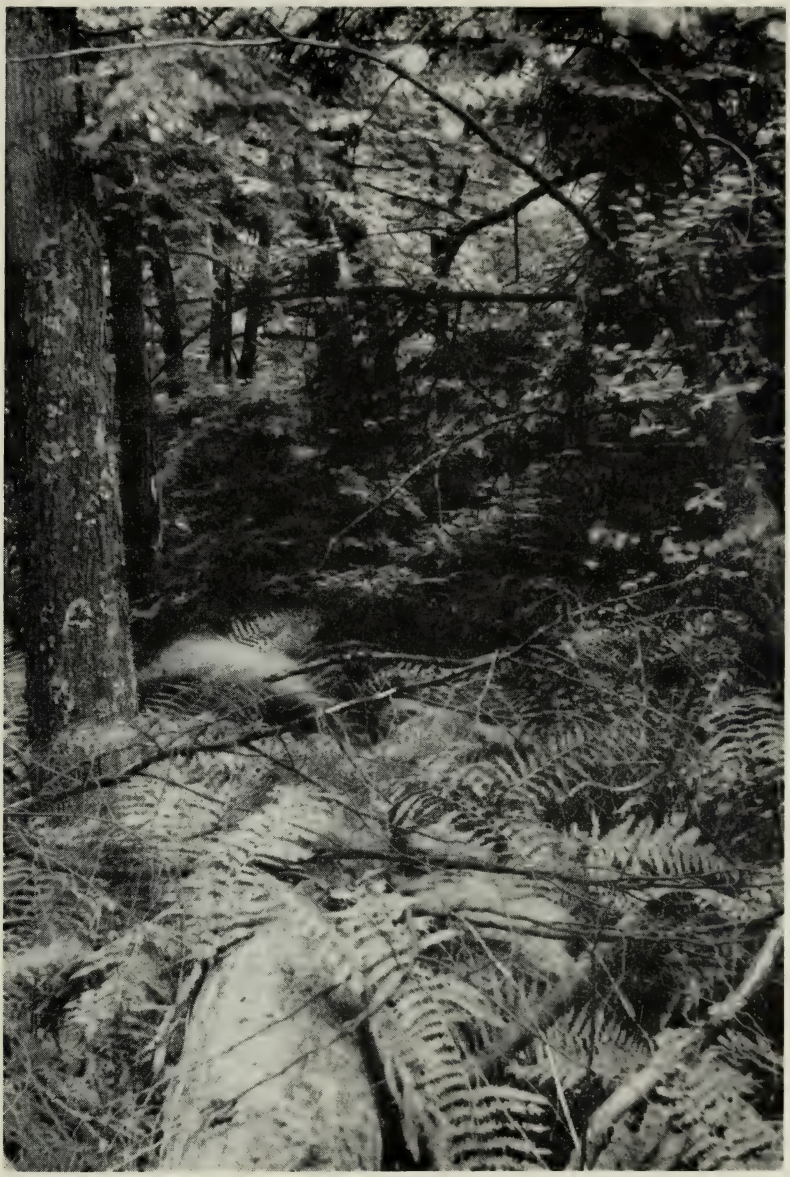

FIG. 17. Swamp forest at northern end of Aurora Pond. Red maple and hemlock.

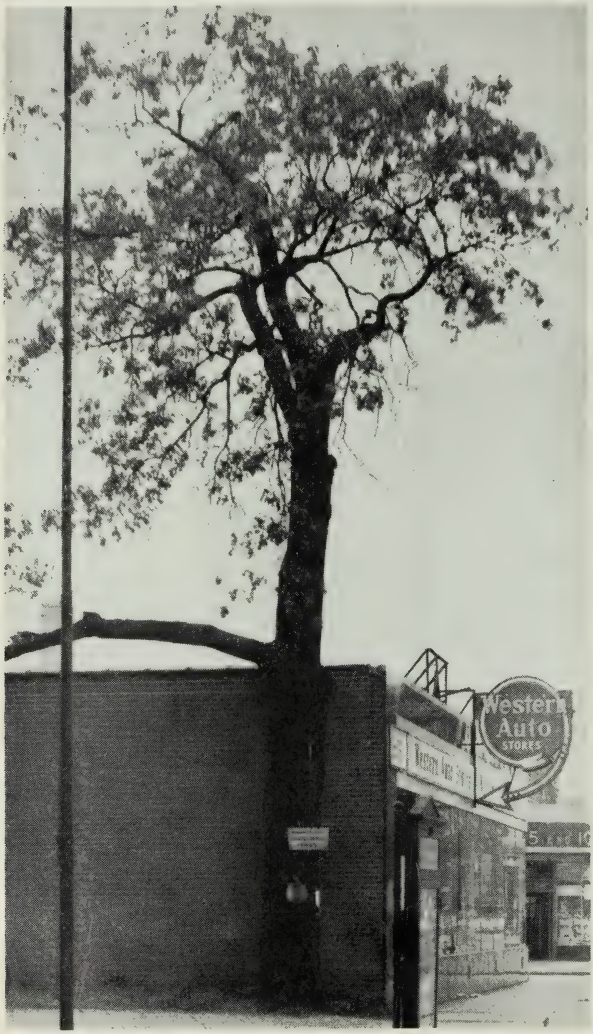

FIG. 18. Black oak at Emmanuel Episcopal Church, 8614 Euclid Avenue Cleveland. The sole survivor (1946) of a famous grove of black oaks and tulips in this locality. It measures 33.5 inches dbh.

The early accounts of the settlement of Cleveland contain scanty references to the character of the original forest. We have already noted Moses Cleaveland's brief description (p. 28). John Heckewelder, the Moravian missionary, antedates Moses Cleaveland on the banks of the Cuyahoga by several years. He has left this description of the country "next to the lake". "Well timbered either with Oaks and Hickory or with lofty Chestnuts" (Heckewelder, 1796). On May 10, 1813, Captain Sholes came to Cleveland with a company of soldiers. He mentions "a forest of large timber (mostly chestnut) between the lake and the lake road." (Whittlesey, 1867).

Clearing of the land proceeded slowly at first. By 1817 the population of Cleveland was only 250 persons. Even as late as 1835 there were still "groves of fine black oaks and chestnuts on Erie (East 9th) Street between Superior and Prospect Streets, and a good many on the northeast part of the Public Square between St. Clair and the lake" (Cleveland, 1896). Nevertheless, the first concern of those who settled upon the land was to clear away the forest as completely and as rapidly as possible, and it is astonishing with what thoroughness it was done. None of the old photographs of Cleveland which the writer has inspected shows any large trees.

A brief glance into these forest clearings in what is now downtown Cleveland is given by Gilman Bryant, who wrote in 1797, "There was no cleared land only where the logs were cut to erect the cabin, and for firewood. I saw the stakes at the corners of the lots among the logs and large oak and chestnut trees." (Whittlesey, 1867).

Samuel Huntington, telling of a visit to Cleveland in 1800, wrote, "Explored the city and town; land high and flat, covered with white oak." (Whittlesey, 1867).

Said Robert Engle in 1816, "I wouldn't then have taken a farm in Cleveland as a gift; it was nothing but a sandbank surrounded by scrub oaks." (World's History of Ohio, 1896).

The foregoing seems to indicate that this central section of the lake plain, where the City of Cleveland now stands, was formerly occupied by a mixed forest, the character of which varied with topography, drainage and character of soil.

In this forest, chestnut, black oak, white oak, white ash, beech and tulip played a prominent part, especially on the better drained land and sandy ridges, while sugar maple, so prominent in the forests of the uplands, was here in a minor position.

The wetter places were occupied by the lowland swamp forest of American elm, black ash and silver maple, or by the characteristic stands of pin oak, in which tupelo regularly appears as a lesser element. Apparently black walnut and butternut were not uncommon, and doubtless sycamore, which is usually a stream edge tree, may have been a more or less frequent associate of the American elm. Hemlock was present in swamps and gullies, but was not common.

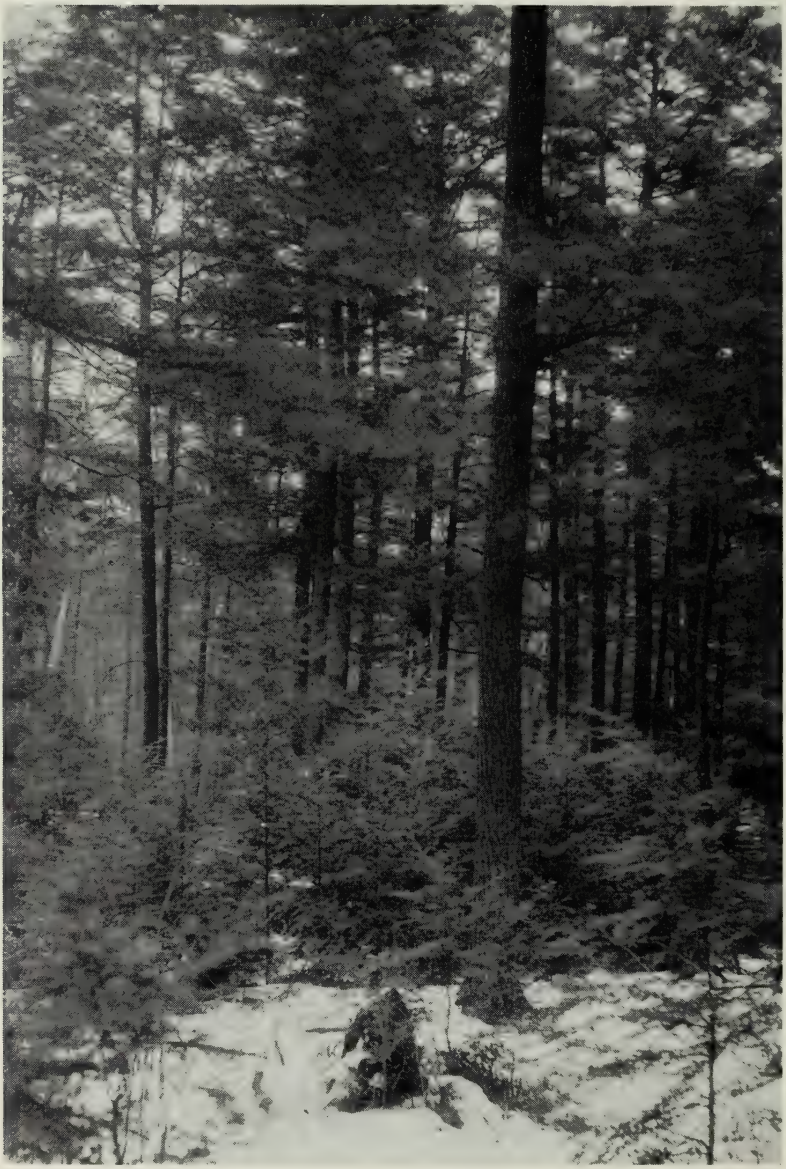

FIG. 19. A stand of hemlock near the escarpment edge overlooking the Chagrin Valley.

On the slopes of the shallow stream valleys and in the short gullies through the lake cliff, the characteristic species of the beech-maple association would appear.

C. *Western Section* — In this section of the lake plain at the present time there are few old forest remnants except in the valley of Rocky River within the Cleveland Metropolitan Park System (1906 acres). Here, on the sides of the valley walls, when not too steep, and on lands above flood plain level, the beech-maple forest, with its characteristic associated species, occurs. At the top of the slope the common trees are black oak, red oak and white oak.

That part of the valley of Big Creek which lies within the Cleveland Metropolitan Park System, particularly between Snow Road and Stumpf Road, contains some large beech, sugar maple, tulip, white ash, tupelo, basswood and white oak.

The flat top of "Mount Pleasant", in the Rocky River Valley south of the Brookpark Bridge, has apparently never been more than partially cleared. Its eastern two-thirds still retains a goodly number of trees well over 150 years of age. They are such as to indicate clearly a beech-maple association. There are a few white oaks, and about the edges of the mesa are black oak, red oak and chinquapin oak. As this "hilltop" is an isolated and relatively undisturbed piece of land, formerly a part of the neighboring flat lake plain until cut off by the action of the river, its vegetation can be assumed to represent the character of the forest that formerly occupied the cleared farming country on both sides of the valley.

Near the western line of the county, on the south side of West Lake Road, there existed in 1939 a small piece of relatively undisturbed woodland. This flat wet area supported a dense stand of pin oaks, among which were several large old trees. Where the land was a bit higher, a few red oaks and white oaks appeared. There were also a few tupelo trees of smaller size.

Frequent isolated examples of pin oak in large sizes occur throughout the section. Other large old trees are white oak, red oak, black oak, swamp white oak, bur oak, scarlet oak, chinquapin oak, American elm, silver maple, tupelo, cucumber, white ash, and remains of chestnut. In the swampy areas behind the sandy ridges occur a few old trees of cottonwood, American elm, silver maple and red maple. (see Figs. 23, 24).

Although at the present time remains of beech are rare west of Rocky River, they do occasionally occur. On the other hand, beech holds a dominant position in this region in the records of certain early road surveys preserved in the Cuyahoga County Engineer's office. In making these

surveys it was the custom, when running the line through the forest, to mark a tree at intervals of one mile, or even at times whenever the direction of the line changed.

In 1810 the road known as the "Rocky River-Hogsback-Mastick-Columbia Road" was laid out by surveyor Ira P. Morgan. This road ran from the mouth of Rocky River, on its east side, to the "hogsback", at an angle in Riverside Road near the southerly line of the City of Lakewood. From that point it descended into the valley, crossed the river, and ascended the cliff on the opposite side. From this point it proceeded south and southwest near the lines of the present Wooster Road and Mastick Road to Columbia Road, which passes south through Olmsted Falls. Of the 11 "mile trees" noted on this survey, 10 were beech, and 1 maple.

In 1811 the road known as "Center Ridge Road" was surveyed by Ira P. Morgan. This road, running westerly from Rocky River along the old beach of glacial Lake Whittlesey, is essentially the Center Ridge Road of today. Fifteen "mile trees" are noted, of which 10 are beech, 2 oak, 1 white ash, 1 maple, 1 whitewood (tulip).

In 1816 the road known as the "Fisher-Triskett-Lorain-Columbia Road" was surveyed by Samuel S. Baldwin. This road ran substantially along the lines of the present Berea, Triskett and Lorain Roads and Riverside Drive, crossing the east branch of Rocky River at Berea to meet Columbia Road west of the river. Thirteen "mile trees" are noted, of which 8 are beech, 1 white oak, 1 elm, 1 hemlock (near the river crossing), 2 no record.

In 1817 the road known as the "Columbia-Mastick-Wooster Road" was surveyed by Alfred Wolcott. This road, starting in Columbia Township, Lorain County, followed essentially the course of Columbia, Mastick and Wooster Roads of today, to the present City of Rocky River. In the 14½ miles of its course in Cuyahoga County there are 92 changes in direction recorded in the surveyors' notes. At each of these points the species of tree encountered is recorded. Of these, 47 are beech, 11 "Sugartree" (sugar maple), 9 white oak, 5 chestnut, 5 ironwood, 2 "Gunnwood" (black walnut), and 1 each of hemlock, hickory, poplar, and maple. The remaining nine points are represented by stakes or obscure records.

In 1819 an "alteration" of the "Wooster Pike" was surveyed by Zara D. Howe. This was substantially the present Wooster Road. Of 8 "mile trees" recorded, 5 are beech, 1 hickory, 1 maple, 1 white oak.

Taken together, these surveyors' records figure 60 per cent beech, 10 per cent oak, and 8 per cent sugar maple. It should be noted that these roads followed the higher and better drained portions of the land, some of them being located on the sandy ridges of the old glacial lake beaches.

There are some fine old sugar maples along the roadside on these beaches today, but Mr. H. E. Willard is of the opinion that these trees were planted by human hands. Their more or less even spacing would also suggest this.

Apparently this western and southwestern section of the lake plain was formerly occupied by a number of forest types which varied with the topography and drainage of the land. In the wetter locations along the Lake Erie shore, and often in poorly drained locations elsewhere throughout the area, dense stands of pin oak were common. Associated with these were swamp white oak, bur oak and tupelo. Characteristic of some of these communities was sphagnum moss and buttonbush (*Cephalanthus occidentalis*). On areas where the water table was lower, white oak, red oak, black oak and chestnut occurred. There are also enough evidences of scarlet oak to include this species as at least an occasional constituent of this mixed oak forest. For the first time, chinquapin oak and boxelder appear as characteristic trees. Bur oak is much more common here than on the lake plain farther east. The presence of hackberry and honey locust for the first time should be noted. These appear in the Rocky River Valley. Shagbark hickory and pignut also appear to have been more common here than on other parts of the lake plain.

FIG. 20. Second growth white oak, Brecksville Metropolitan Park.

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FIG. 21. Characteristic ravine cutting through the escarpment, tributary to Euclid Creek. Hemlock and beech-maple.

Wherever the water table was low enough, and the land was not too dry, beech, tulip, cucumber, white ash and occasional sugar maple — in other words, the typical beech-maple association of the region, would have been found. This was true particularly of the slopes of the larger valleys, the stream beds of the smaller streams, and the gullies of the lake cliff.

On the dry ridges, represented by the old beaches of glacial lakes, beech, white oak, black oak, chestnut, tulip and white ash made up the bulk of the forest. In the swampy areas behind the beaches grew forests of American elm, silver maple, boxelder and black ash.

In this western section of the lake plain in Cuyahoga County we approach more closely to the conditions of the old "Black Swamp" of pioneer days, which occupied a large part of the lake plain farther west in Lorain and other northwestern counties. The black swamp is all drained now, and little remains of the original forest. The Toledo Metropolitan Park (on the lake plain about 80 miles west of Cuyahoga County) includes a remnant of this forest. Its main constituents are American elm, black ash, red ash, white ash and silver maple. Large elms and maples predominate. There are also some sycamore, cottonwood, basswood, bur oak, swamp white oak, chinquapin oak, red oak, and shagbark hickory in large size. Among the smaller sized trees are some tulip, boxelder, American hornbeam, bitternut and papaw, with an occasional beech. Poison ivy is abundant.

One must not lose sight of the fact that the situation here is now much drier than formerly, and the probability is that such species as beech and tulip may be relatively recent arrivals. It was, however, to a forest of this type that the forest of the western section of the lake plain in Cuyahoga County was approximating.

5. *Till Plain* — The till plain within the county (see Fig. 1) is a relatively small, flat area, now practically devoid of trees. It is quite evident that it once contained many more wet and swampy places than now appear. A famous swamp was the so-called "Podunk Swamp", which lay somewhat to the southeast of the present Cleveland Airport. Here also is Abram's Lake, which now occupies but a small portion of its original site (see p. 13).

Mr. Albert Smith, over 80 years of age, told the writer that he has lived beside Abram's Lake ever since he was a small boy, and that behind the willows that once fringed the lake's edge there stretched a forest of elm, black ash and "soft maple" (identified later as silver maple). There was no beech, sugar maple or hemlock in the neighborhood.

Dr. T. D. Gould, of Lodi, Ohio, remembers Abram's Lake as it appeared about 1858. "The forest growth about there, as it was over most of that region," he writes, "was soft maple and elm predominating, drainage being difficult there. In fact, the Cleveland Airport, was at that time a part of

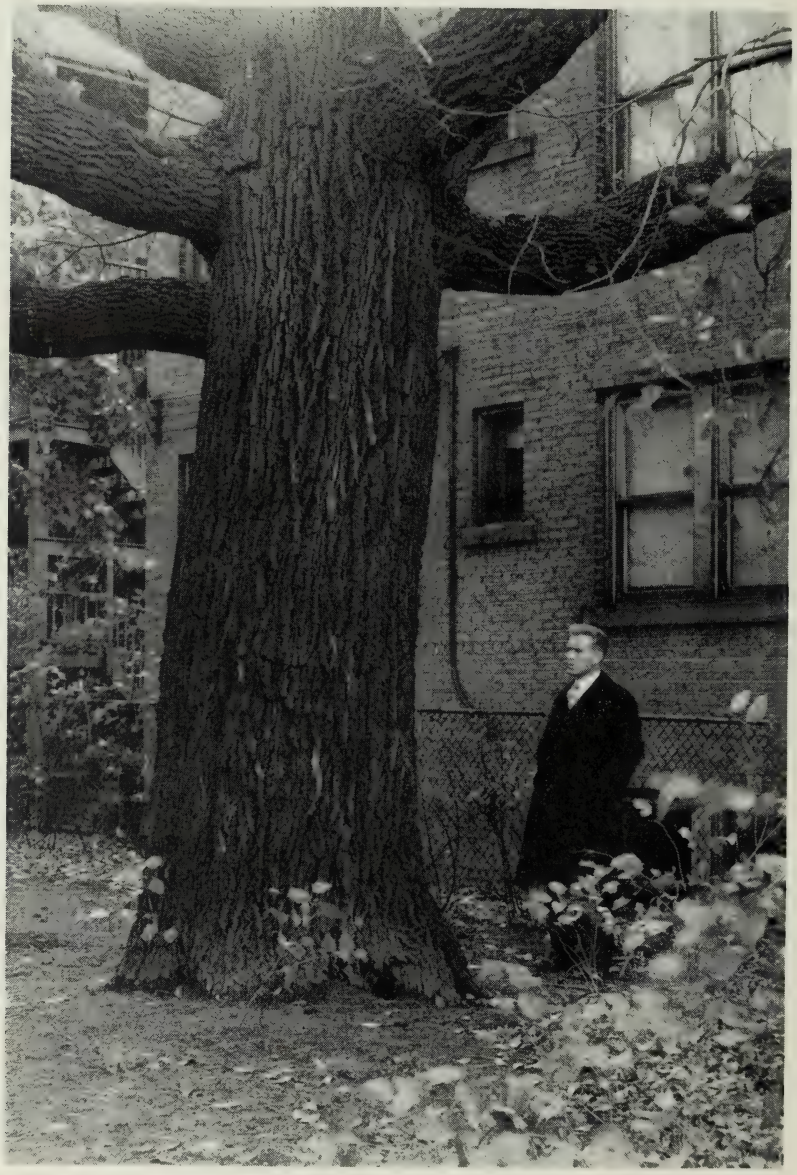

FIG. 22. White ash at 10010 Detroit Avenue, Cleveland. It measures 4 feet 1 inch dbh.

this same type of land. My recollection goes back to the time when the road along the east side of the Airport was corduroy, with water in the ditch's side until mid-summer." And again, "Several lesser swamps in the immediate neighborhood of Lake Abram were caused by beaver dams that blocked their outlets."

Cuyahoga County's southern boundary just misses the line of post-glacial bogs that are located on or near the summit of the watershed which passes through contiguous Summit and Geauga Counties. Abram's Lake, however, was such a bog, and probably once supported about its edges a growth of tamarack and white pine, such as now may be seen in the bog to the south of Fern Lake in Geauga County, or such as formerly existed about Solon bog, almost on the Cuyahoga County line. (Aldrich, 1943).

Besides the extensive swamp forests of elm, ash, and maple, certain large pin oaks, white oaks, and swamp white oaks on the till plain indicate the presence formerly of the "wet oak" type of forest, of which the "pin oak flat" is the extreme example. In May, 1941, the writer inspected the remnants of such a forest in New London, Huron County, Ohio, about 30 miles to the southwest of the locality under discussion. This was a poorly drained area, containing much standing water at the time. Above the more recent forest growth towered a few giant oaks and hickories, the species being pin oak, swamp white oak, bur oak, white oak, red oak, and shagbark hickory. Many of these trees were from 4 to 6 feet in diameter, and 125 feet in height. Probably some were from 300 to 400 years old. They were magnificent specimens which made it possible to reproduce in imagination something of the character of the forest of the same till plain in Cuyahoga County not so far away, in the days before the axe of the white man began its demolition.

In addition to these swampy areas there were numerous locations on the till plain within Cuyahoga County where the water table was low enough to encourage the development of another type of forest. A few large trees of beech, white ash, and white oak, associated with more recent growth of beech, sugar maple, cucumber, basswood, tulip and tupelo, suggest that the beech-maple association was probably in possession of the less wet portions of this small area of till plain.

In summary, we may conclude that the oaks probably occupied much of the level lands of the till plain. Pin oak, swamp white oak, and bur oak, with shagbark hickory probably were the dominant species; while white oak and red oak appeared on the drier lands. In certain favorable locations, beech, tulip, white ash, basswood, cucumber and tupelo would have been present. But over much of the area the lowland swamp forest of American elm, black ash, and silver maple held sway.

6. *Flood Plains and Stream Valleys* — John Heckewelder, previously quoted (p. 46), writes that the Cuyahoga bottomlands were timbered with "either Black Walnut or White Thorn Trees, intermixed with various other Trees as Cherry, Mulberry, etc. The ground entirely covered with high nettles." "In such bottoms somewhat inferior to the above, the Timber is principally lofty Oaks, Poplar or Tulip Tree, Elm, Hickory, Sugar Maple, yet intermixed with black Walnut, Cherry, Mulberry, Grape Vines, White Thorn, Haw bush, etc., etc., Ash, etc." At the old Moravian Town (near mouth of Tinker's Creek) he mentions "very lofty Sycamore Trees." (Heckewelder, 1796). J. D. Cleveland, previously quoted (p. 47), says that in 1835 "the Scranton flats were covered with Great Meadows, and the Stone flats by the primeval forest of black walnut, hickory and chestnuts." (Cleveland, 1896).

Alfred Wolcott in 1811 wrote in his surveyor's record book, "As the Cuyahoga bottoms generally are — with Black Walnut, Ash, some Elm, Bass, Buck Eye, Plumb and Crabtree." We thus have several eye-witness characterizations of the original forest of the flood plains of the Cuyahoga.

Fortunately, we are able to amplify these brief descriptions by means of detailed studies of many remnants of original flood plain forests in the valleys of the Chagrin, Cuyahoga and Rocky Rivers, as well as of smaller streams, such as Euclid Creek and Doan Brook; and also through the personal recollections of a few men who recall the character of forests long since removed.

Mr. Don Knowlton speaks of the Cuyahoga bottomlands in the neighborhood of Clark Avenue (see Fig. 3) in 1900 as then wooded with "extremely large" and numerous buckeyes, cottonwoods, and boxelders; and on the second level, or terrace, butternuts, American elms and silver maples. He particularly recalls a large Ohio buckeye, perhaps 80 feet high, in the valley near the Clark Avenue Bridge.

Black walnut particularly stands out as a tree of these bottomlands. Mr. Oliver Upson told the writer that the building of the Upson-Walton Company, located at the Cuyahoga River edge at West 11th Street, Cleveland, was originally built in 1865. Extensive repairs were made in 1925 or 1926. At this time, he says, excavations made at the four corners of the building disclosed that it rested upon a "mattrass of black walnut logs". This would seem to indicate that black walnut was not a difficult timber to procure in the neighborhood of West 11th Street near the river a little less than 100 years ago.

Mr. George Mastick, whose family tradition in the neighborhood of Mastick Road in the Rocky River Valley goes back for well over a century, mentioned to the writer the prevalence of black walnut as a tree of the

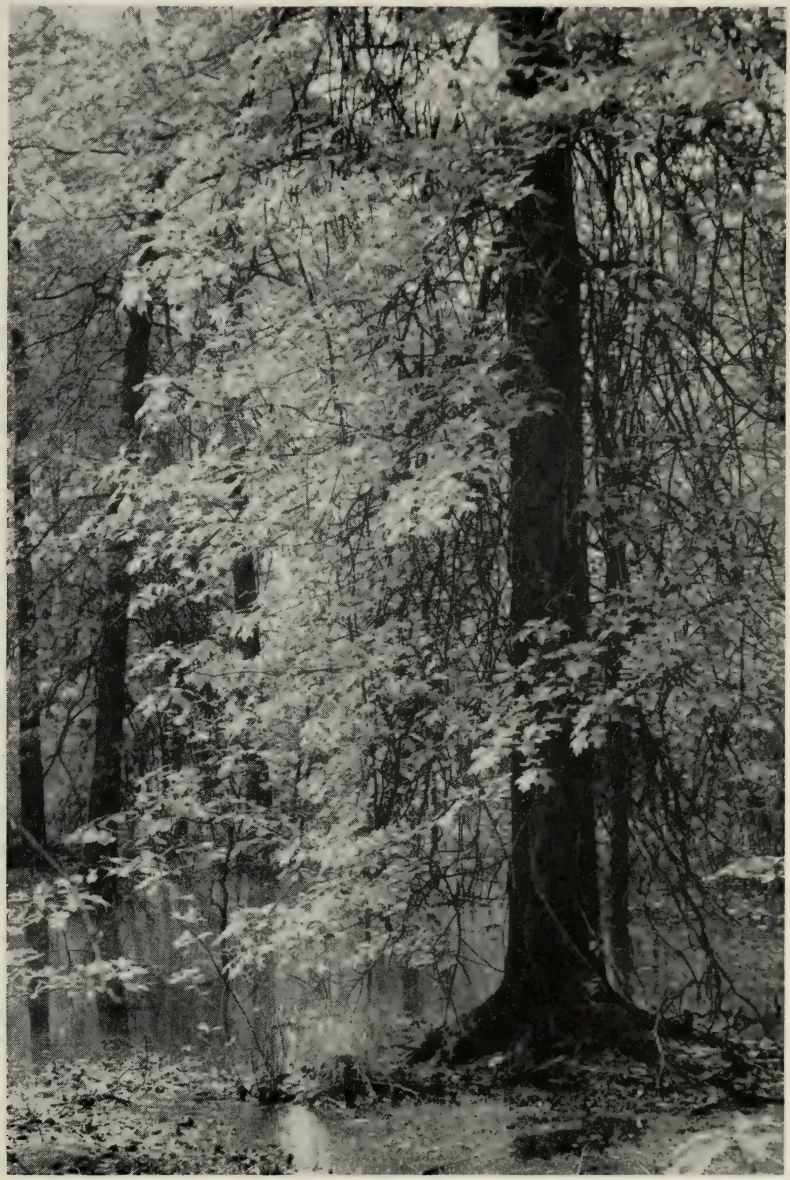

FIG. 23. Pin oak in small swamp, Brecksville Metropolitan Park.

valley where he lived for over 80 years. According to Mr. Mastick, this was the tree that furnished the material for the log cabins and fence rails of the early days in the vicinity of his home.

Mr. Frank D. Johnson recalls the "whaling big black walnuts" that were cut in the Rocky River Valley during his boyhood days (1885), which dotted the valley almost to Lake Erie.

During the extensive highway improvement operations at Willow, in the Cuyahoga bottomlands a few years ago, black walnut logs, buried under river deposits, were unearthed by the steam shovels. Some large silver maples and cottonwoods were removed from the river bottom land nearby at this time.

The writer has investigated in detail many localities where large trees of the river bottom or flood plain forest still survive within Cuyahoga County. It is very apparent that this was formerly a forest of giants, only a few of which still remain. (see Figs. 6, 25, 26).

Along the river edge, sandbar willow, black willow and heart-leaved willow are now common species. In the wetter locations, sycamore, cottonwood, American elm, slippery elm, and boxelder predominate. As the water table becomes lower, the two elms become more common; while black walnut, butternut, Ohio buckeye, black maple and big shellbark hickory appear in numbers. Less common trees are black ash, red ash, basswood, red mulberry, wahoo, bitternut hickory, red maple and silver maple. In certain wet locations swamp white oak and bur oak occur. Groves of papaw are not infrequent, and occasionally a few wild plum trees are encountered. Thorns (*Crataegus*) commonly occur along the river edge and are usually mentioned by the early surveyors. (see Fig. 28).

The writer feels that the foregoing was essentially the composition of the flood plain forests of 150 years ago, as it is today, in the Cuyahoga and Rocky River Valleys. The Chagrin Valley lacked the abundance of Ohio buckeyes, boxelders and black maples of the valleys of the lake plain section of the county.

Not only was this forest rich in species of trees, but it was also rich in species of lesser plants, including many climbers and twiners. Its understory was dense and rank with tall, weedy perennials, such as cow parsnip (*Heracleum lanatum*), (see Fig. 27), and in places well-nigh impenetrable. Its level lands, when cleared, became the most fertile and easily worked of farm lands throughout the county. (see Fig. 4).

Extensions of these flood plain forests occurred also on the small flood plains of tributary streams, and often extended far up into the gullies and ravines of the uplands. As the land became higher, however, the slopes and

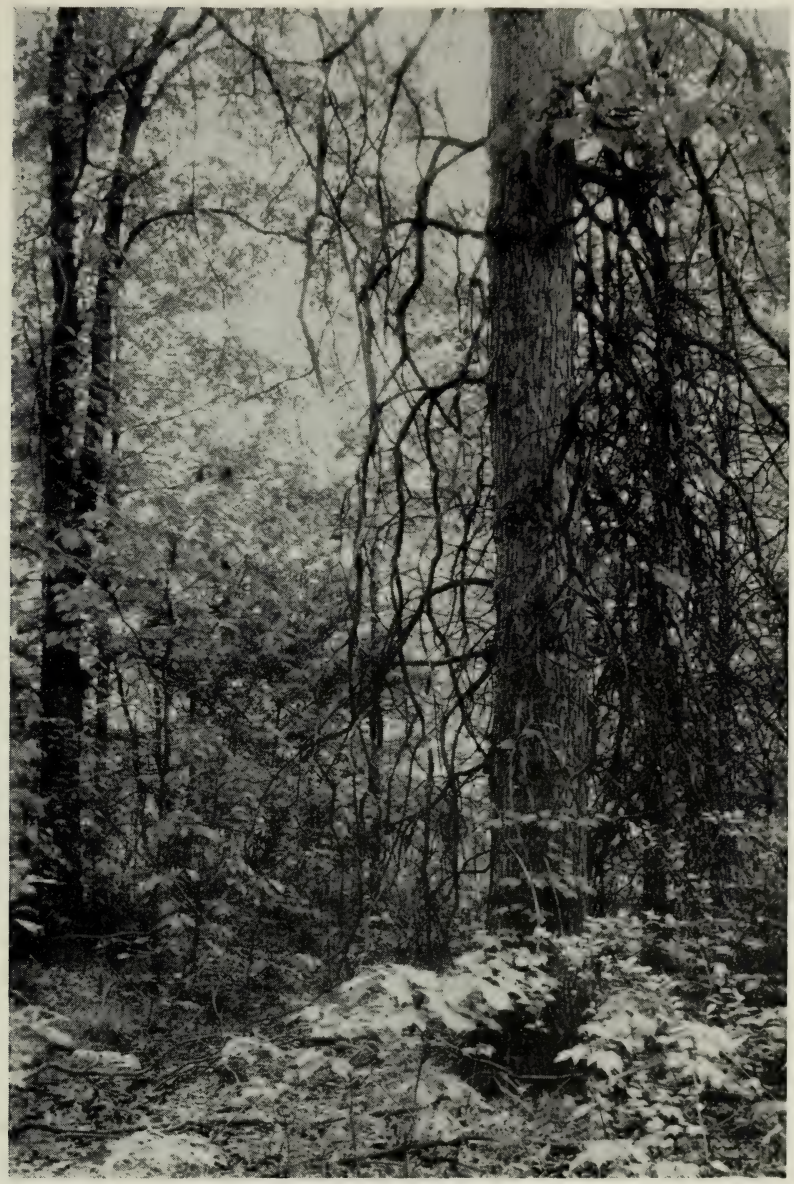

FIG. 24. Swamp white oak in small swamp. Brecksville Metropolitan Park.

bottoms tended more and more to be taken over by the beech-maple association, often including hemlock.

7. *Lake Erie Beach Line and Contiguous Marshes* — The trees of the lake beaches were largely cottonwoods and willows, and due to the unstable character of the habitat, they probably did not formerly, as they do not now, succeed in attaining to large size.

FIG. 25. The largest sycamore. It stands on the Flood Plain of the East Branch of Rocky River north of Berea. The trunk is completely hollow and large enough to accommodate a card table with four people sitting about it in chairs. It measures 9 feet 5 inches dbh.

In a few places where limited areas of sand dunes afforded a better foothold, a thin forest of cottonwood, black oak, red oak, bur oak, pin oak, white ash and basswood, in varying combinations, would have developed. In this association wafer-ash (*Ptelea trifoliata*) was a common shrub. An illustration of such a community exists at the present time just beyond the eastern limits of the county at Richmond Beach, just west of the mouth of the Grand River. Probably this type of forest also once bordered the marsh on the west side of the Cuyahoga River near its mouth before the true flood plain forest was reached. (see Fig. 5). Wherever the lake cliffs bordered the water there was no transition from interior forest to shore line conditions.

SUMMARY

The following paragraphs summarize briefly the detailed account of the forests of Cuyahoga County as they existed 152 years ago, as has been indicated in the foregoing pages. A simple statement is well-nigh impossible, since the picture is rendered too complex by the factors of topography, soils, drainage, micro-climates and general location at a sort of ecological crossroads in North America.

1. Throughout the region the beech-maple climax forest occupied all available locations in almost unbroken form. This was a forest dominated by beech and sugar maple, usually including as associated species in lesser numbers red maple, white ash, tulip, cucumber and tupelo. Normally it was a high, closed, dark forest with little undergrowth except the seedling trees of the dominants.

Within the county this beech-maple association was practically continuous throughout the eastern highlands; occupied much of the ground in the southern highlands; occupied the slopes of the valley walls, the ravines between the ridges, and the short gullies through the lake cliff; and appeared in modified or fragmented form throughout the lake plain and till plain wherever the soil was not too wet or too dry. Although beech was well represented on the lake plain, apparently sugar maple was not so common here as upon the uplands.

2. Included within the limits of the beech-maple association on the uplands were numerous locations where, because of the swampy character of the land, beech and sugar maple gave way to a typical upland swamp forest of limited and local extent, in which American elm, red maple and black ash were the dominant species. In this upland swamp forest basswood often appeared, and American hornbeam was a rather common understory tree.

3. Where the beech-maple association approached the edge of the escarpment, and the soil became less capable of holding moisture, an oak-chestnut association of limited extent appeared. The oaks were white oak, red oak, black oak, scarlet oak — and along the escarpment edge of the eastern highlands — chestnut oak. Chestnut in this location was an abundant species. Shagbark hickory, pignut, hophornbeam, flowering dogwood and shadbush reached a better degree of development here than elsewhere.

4. On the spurs overlooking the valleys, along the edges of the gorges, and within the cool, damp ravines, hemlock and white pine were commonly found. Of these, hemlock often formed extensive, practically pure stands. Where hemlock came into contact with the beech-maple forest, a tension zone existed, which often resulted in a mixture of beech and hemlock which might properly be called a beech-hemlock association. In the ravines, on

FIG. 26. The largest big shellbark hickory. It stands on the west bank of Rocky River just south of the Puritas Springs Road Bridge. It measures 34.5 inches dbh.

the other hand, hemlock was frequently associated with yellow birch, black birch and American yew. On the lake plain hemlock appeared as a tree of the swampy areas, where it was associated with red maple, silver maple and black ash.

White pine was not an abundant tree in Cuyahoga County even 150 years ago. On the slopes of the valley walls occasional large individual trees might have been found, and in a few places small groves of white pines associated with hemlocks were known to have occurred.

5. On the southern highlands a forest of oak, hickory, and chestnut was particularly well developed on the ridges. The species were white oak, red oak, black oak, scarlet oak, chestnut, shagbark hickory, pignut and white ash. Some exceptionally fine, almost pure stands of white oak were known to have occupied the north-facing slope of the escarpment here.

6. The drier portions of the lake plain and till plain supported a mixed forest in which black oak, white oak, red oak, tulip and white ash were the common species. On the sandy old lake beaches black oak particularly was an abundant tree. To a lesser degree scarlet oak, and (particularly westerly) chinquapin oak appeared. Beech was a not infrequent member of this mixed forest.

7. The very considerable swampy areas on the lake plain and till plain were mostly occupied by lowland swamp forests in which American elm, silver maple and black ash dominated. Frequently associated with these species were slippery elm, bur oak, swamp white oak and bitternut hickory.

8. Other wet lands on the lake plain and till plain frequently supported dense, almost pure stands of pin oak. Sometimes associated with the pin oaks were tupelo, swamp white oak and silver maple. It is probable also that these "pin oak flats" might have been present to a limited extent in suitable wet locations on the eastern and southern highlands.

9. Although unsupported by existing evidence, it seems reasonable to infer from the vegetation of similar sites contiguous to Cuyahoga County that tamarack and white pine might well have been present about Abram's Lake.

10. The bottomlands of the Rocky River, Cuyahoga and Chagrin Valleys were occupied by typical northern Ohio flood plain forests, which usually extended into the smaller valleys of tributary streams, even sometimes appearing in fragmentary form in the bottoms of ravines and gullies leading into the uplands.

At the stream edges, sandbar, heart-leaved, and black willow were common species. In the wetter locations, cottonwood and sycamore flourished and grew to large size. As the water table lowered slightly, American

elm, slippery elm, black walnut, and butternut became common. In lesser numbers, red ash and black ash were found along the streams, and occasional groves of papaw, wild plum, American crab and thorns were developed. In the Rocky River Valley at least, wahoo and red mulberry were occasional understory species. In the Cuyahoga and Rocky River Valleys Ohio buckeye, boxelder, big shellbark hickory, and black maple were abundant species, but these were apparently rare or not present in the Chagrin Valley.

FIG. 27. Flood Plain vegetation, Rocky River Valley. Sycamore, box elder, cow parsnip and stinging nettle.

11. On the exposed faces of the shale cliffs of the valley walls, and particularly where glacial till was eroding, red cedar and common juniper grew.

12. Wherever sand beaches were established along the Lake Erie shore, sandbar willow, black willow, cottonwood, and occasionally basswood, bur oak and red oak were characteristic species.

13. In areas where secondary succession was in progress it seems reasonable to infer that the order of succession would have been largely that of the present time, which includes thorns, crabs, sumacs (both staghorn and smooth), aspens (both large-toothed and quaking), wild black cherry, sassafras, red oak, shagbark hickory, white ash, red maple, American elm, tulip and tupelo as usual early arrivals, depending on character of soil and proximity of various types of forest units.

VI.

GENERAL ECOLOGICAL RELATIONSHIPS

From the foregoing, it would appear that the native forests of Cuyahoga County are a part of the great Deciduous Forest Formation of northeastern North America. In fact, the county lies well within the limits of this formation as described by Weaver and Clements (1929).

Northern and eastern vegetational affiliations are suggested by the presence here of hemlock, white pine, yellow birch, black ash and mountain maple. These northern and eastern species occur here close to their western and southern limits of distribution. According to Nichols (1935), Cuyahoga County appears at the southwestern edge of the irregularly outlined region which he designates as the "Hemlock-White Pine-Northern Hardwood Region" of eastern North America.

Also evident within the species composition of Cuyahoga County's forests are distinctly western and southern elements, as indicated by the presence of such species as honey locust, hackberry, chinquapin oak, big shellbark hickory, Ohio buckeye, cucumber tree and tulip — all of which are here close to their northern or eastern limits of distribution.

Still another western influence is reflected in the probability that Cuyahoga County once contained small areas of prairie character. Although Transeau's map of the Prairie Peninsula (1935) does not show any outliers of the western prairies within its limits, we find Samuel Huntington, writing of a visit to Cleveland in 1800, reporting that "on the west side (of the Cuyahoga River) is a prairie where one hundred tons of hay might be cut each year." (Whittlesey, 1867). Assuming a yield of one ton of hay per acre, we may take this reference as indicating an area of about 100 acres. At the present time this location is so fully occupied by streets and buildings that all traces of its original vegetational character have long ago disappeared. (see Fig. 5).

It thus appears that Cuyahoga County, ecologically speaking, is on the tension line between eastern and western, northern and southern plant associations. This spectacular meeting and overlapping of forest communities within the limits of a single small county in northern Ohio is due in great measure to its unique position with reference to great continental physiographic boundaries, which has already been noted (see p. 6), coupled with the fact that its climate is also transitional between that of the east coast and the continental interior (p. 17).

Although Lake Erie seems to form a natural barrier to the extension of southern species northward, northern species reach the region by way of the lake shore, which from Cleveland extends toward the northeast.

It might be added that this overlapping of plant communities in the county is somewhat paralleled by a similar overlapping of animal forms. (Bole and Moulthrop, 1942).

The fact that Cuyahoga County is thus situated at a veritable ecological crossroads is indicated in many ways, but perhaps not more dramatically than in the distribution of its trilliums. To the east, on the plateau, *Trillium grandiflorum* is the abundant trillium; *Trillium sessile* is conspicuously absent. To the west, on the lake plain, *Trillium sessile* is abundant; *Trillium grandiflorum* is rare or absent.

FIG. 28. Rocky River, showing flood plain forest.

VI.

THE "MOSES CLEAVELAND TREES"

Before bringing this account of the native forests of Cuyahoga County to a close, it may be of more than passing interest to record the labeling of the "Moses Cleaveland Trees". This was a project undertaken in connection with Cleveland's Sesquicentennial celebration in 1946. It involved the selection and labeling of 150 old trees (one for each year of the city's life), distributed throughout Cuyahoga County in places where they might easily be seen and appreciated by the public.

In each case the tree was judged to be more than 150 years old, so that it represented the "original" forest of Moses Cleaveland's day. The writer was chairman of the committee which undertook this work.

The labels were of aluminum, 10 by 5 inches in size, with etched lettering filled in with red enamel. One reads as follows:

BLACK OAK

Quercus velutina

This is a Moses Cleaveland Tree. It was standing here as a part of the original forest when Moses Cleaveland landed at the mouth of the Cuyahoga River July 22, 1796. Let us preserve it as a living memorial to the first settlers of the Western Reserve.

The Sesquicentennial Commission

When the trees were all chosen, it appeared that 23 different species were represented. These were:

White Oak	35	Black Walnut	3
Sugar Maple	19	Cucumber	2
American Elm	13	Bur Oak	2
Beech	12	Cottonwood	2
Black Oak	9	Silver Maple	2
Pin Oak	9	Sassafras	2
Red Oak	8	Swamp White Oak	2
Tulip	7	Scarlet Oak	2
Red Maple	6	Chestnut Oak	2
White Ash	4	Big Shellbark Hickory	1
Tupelo	4	Hemlock	1
Sycamore	3		

Some of these trees are shown in the preceding pages (see Figs. 6, 7, 8, 9, 15, 18, 22, 25, 26).

It will be noted that white oak stands at the head of the list in numbers. This appeared to be the species best equipped to survive to old age in fairly good condition, and to maintain itself successfully against wind damage and fungus attack.

CHECK LIST OF TREES
CUYAHOGA COUNTY, OHIO

I.
NATIVE TREES

The order of arrangement in the following list, and the scientific names used, are, with a few exceptions, as found in *Trees of the Eastern United States and Canada*, by William M. Harlow, 1942. It is to be understood that the remarks below, unless otherwise indicated, refer only to the species as it occurs in Cuyahoga County, Ohio, and in its native state. Measurements given are taken breast high with steel diameter tape. While many good examples of native trees may be found growing along city streets, the locations given herein usually refer to the tree in its natural environment.

Eastern White Pine — *Pinus strobus* L.

Formerly present in small isolated stands or as individual trees, usually associated with hemlock, on the spurs, ridges and steep slopes of the valley walls of the Chagrin and Cuyahoga Rivers and their tributary gorges and the gorges of the escarpment edge. Now found in its native state only as a few scattered individual trees. A tree of more northerly relationships, it occurs here at about its southern limits except as it may grow at higher elevations in the Appalachians. Good examples of small stands of old trees close to the Cuyahoga County line in Lake County may be seen in the North Chagrin Reservation of the Cleveland Metropolitan Parks, and on Little Mountain. Occasional isolated trees occur on the east slope of the Cuyahoga Valley.

Tamarack — *Larix laricina* (DuRoi) K. Koch.

Never abundant in Cuyahoga County, its distribution here was limited to the margins of postglacial bogs, such as Abram's Lake. A tree of the north, growing almost to the Arctic Circle. Here near the southern limits of its range. Good examples may be seen in Geauga County at Fern Lake and swampy ground to the south.

Eastern Hemlock — *Tsuga canadensis* (L.) Carr.

Our most common native evergreen tree. Formerly abundant in gorges and ravines, and on spurs overlooking the valleys. Has long been in process of displacement by the deciduous forest, and within the county limits is gradually diminishing in numbers. Often with beech it forms a beech-hemlock association. A tree of more northerly relationships, it represents, with white pine and yellow birch, a more boreal type of forest than that now occupying the land. Good examples of native hemlock are still to be seen on the spurs overlooking the Chagrin Valley in the North Chagrin Metropolitan Park, and in many small ravines. (see Fig. 19, 21).

Eastern Redcedar — *Juniperus virginiana* L.

Occasional only. While elsewhere it is often associated with swampy locations, here it occurs in much the same situations as does common juniper (below). A rather common tree of practically all of the United States east of the prairies. Good examples may be seen near the Trailside Museum in the Brecksville Metropolitan Park.

Common Juniper — *Juniperus communis* L.

Occasional only. Most frequently found as a small stunted tree on dry cliffs of glacial drift, or dry exposed banks of soft shale. Otherwise on poor or rocky soil. The variety *depressa* occurs also in much the same locations. A tree or shrub of northern affiliations and circumpolar in distribution. Examples may be seen on some of the steep exposed walls of Rocky River Valley and (*depressa*) near the Trailside Museum in the Brecksville Metropolitan Park.

Black Willow — *Salix nigra* Marsh.

Our most tree-like native willow, common along streams and edges of ponds. A tree of the eastern U. S. and southern Canada. Common as a riveredge species in Rocky River Valley. A specimen of rather poor form may be seen on the westerly side of the small pond at the Forest Lane entrance to the North Chagrin Metropolitan Park.

Peach-leaf Willow — *Salix amygdaloides* Anders.

A rather uncommon small tree or shrub of the Lake Erie shore. A common tree of the northwest and central U. S., here near the eastern limits of its range.

Pussy Willow — *Salix discolor* Muhl.

A common small tree or shrub of stream sides and wet places. A tree of the northeastern U. S. and southern Canada, here near the southern limits of its range. Good examples can be found in almost any wet location where vegetation exists.

Bebb Willow — *Salix bebbiana* Sarg.

A rather rare small tree of wet places such as pond margins and stream sides. A tree of Canada and the northern states, reaching the southern limit of its range here. A small tree of this species may be seen on the easterly side of the pond at the Forest Lane entrance to the North Chagrin Metropolitan Park.

Shining Willow — *Salix lucida* Muhl.

Not uncommon along streams and pond edges. A small tree of eastern

Canada and the northeastern U. S., at about the southern limits of its range here. A good specimen may be seen at the edge of the brook on the south side of Fairmount Road just west of Coventry Road, Cleveland Heights.

Sandbar Willow — *Salix longifolia* Muhl.

This is the abundant willow of sandbars and stream sides, often being the first plant to occupy a newly deposited bar of sand or shale fragments. A small tree or shrub of southern Canada and the northeastern U. S. Can be found on almost any stream, but particularly abundant in Rocky River Valley.

Heart-leaved Willow — *Salix cordata* Muhl.

Frequent along streams, widely distributed through northeastern U. S. Common in Rocky River Valley.

Quaking Aspen — *Populus tremuloides* Mx.

Not so common as largetooth aspen (below) but found in much the same situations. A tree of the far northwest and southern Canada, reaching its southern limits (except as it may grow at higher altitudes in the mountains) in central Ohio. A small thicket stands on the east side of the Park Boulevard south of Brookpark Bridge in the Rocky River Metropolitan Park.

Largetooth Aspen — *Populus grandidentata* Mx.

A common tree of thin woods and woods edges. One of the earliest of the secondary succession species to appear on abandoned lands. A tree of the northeastern U. S. and southern Canada. Examples may be seen about of the Trailside Museum, in the Rocky River Metropolitan Park. Probably Forest Lane Picnic Grounds in the North Chagrin Metropolitan Park.

Eastern Cottonwood — *Populus deltoides* Marsh.

Common in all river and stream valleys and along the Lake Erie shore. Occurs also in many wet, open locations. A regular component of the flood plain forest. A tree of wide distribution in the U. S. and southern Canada, including the Mississippi basin and extending into Saskatchewan and Manitoba. Occurring here toward the eastern limits of its range. Many fine examples may be seen along the Nature Trail, and generally in the vicinity of the Trailside Museum in the Rocky River Metropolitan Park. Probably the largest cottonwood in the county is that standing beside the bridle path near the river edge just south of the Puritas Springs Road Bridge near the Mastick Road entrance to the Rocky River Metropolitan Park. This tree measures 63 inches dbh. (see Fig. 6).

Black walnut — *Juglans nigra* L.

A common tree of river and stream valleys. A regular component of the flood plain forest. A tree of the eastern U. S. and southern Ontario, occurring here near the northern limits of its range. Fine examples may be seen along the Nature Trail, and generally in the vicinity of the Trailside Museum, in the Rocky River Metropolitan Park.

Butternut — *Juglans cinerea* L.

A common tree of river and stream valleys, often associated with black walnut (above). A tree of the northeastern and central U. S. and southern Ontario. Good examples may be seen along the Nature Trail, and generally in the vicinity of the Trailside Museum, in the Rocky River Metropolitan Park.

Shagbark Hickory — *Carya ovata* (Mill.) K. Koch.

The common hickory of the upland woods of the region. A component of the oak-hickory forest and occurring in most mixed woods. A tree of the eastern U. S. and southern Canada, occurring here near the northern limits of its range. A good example stands close to the Trailside Museum in the Brecksville Metropolitan Park.

Big Shellbark Hickory — *Carya laciniosa* (Mx. f.) Loud.

Common in the valley of Rocky River as a tree of the bottomlands. A tree of the eastern central U. S., reaching its northern limit here. A fine example stands on the bridle path along the river edge just south of Puritas Springs Road Bridge near the Mastick Road entrance to the park. (Fig. 26).

Pignut Hickory — *Carya glabra* (Mill.) Sweet.

A rather uncommon tree of the upland woods, occurring either as a component of the oak-hickory forest or as an occasional tree in the beech-maple climax. A tree of the northeastern U. S. and southern Ontario, occurring here near the northern limits of its range. A good example stands on the Nature Trail in the North Chagrin Metropolitan Park.

Bitternut Hickory — *Carya cordiformis* (Wang.) K. Koch.

Common in river and creek bottoms and in other moist situations. A tree of the eastern U. S. and southern Canada. A good example may be seen close to the Wildflower Trail in the North Chagrin Metropolitan Park. A fine tree, 3 feet dbh., stands in the Snow Road Picnic Ground in the Big Creek Metropolitan Park.

Yellow Birch — *Betula lutea* Mx. f.

Common in cool moist ravines and on slopes of valley walls, often associated with hemlock as a remnant of a forest of a colder climate than that of the present time. A tree of the northeastern U. S. and southern Canada, occurring here at the southern limits of its range, except as it may grow at higher altitudes in the Appalachians. Good examples may be seen in Doan Brook ravine near Delaware Road; in the ravine of Dugway Brook, Forest Hill Park; in the ravine of Abram's Creek, tributary to Rocky River Valley.

Black Birch — *Betula lenta* L.

Not uncommon in ravines tributary to the Chagrin Valley and ravines along the edge of the escarpment. A tree of the northeastern U. S., occurring here near the western edge of its range. Two good-sized trees may be seen on the ravine slope near the Trailside Museum in the North Chagrin Metropolitan Park. Smaller trees stand along the Nature Trail in the South Chagrin Metropolitan Park.

Speckled Alder — *Alnus incana* (L.) Moench.

Common in wet places along streams or banks of ponds or lakes, or in swamps. A small tree of northern relationships occurring here at the southern limits of its range. May be seen along the Park Boulevard near the Brookpark Bridge in Rocky River Metropolitan Park, or on the low wet lands at the foot of the bluff east of the Trailside Museum in the North Chagrin Metropolitan Park.

Hophornbeam — *Ostrya virginiana* (Mill.) K. Koch.

A common understory tree of the beech-maple climax and of most mixed woods. A tree of the eastern U. S. and southern Canada. Examples may be seen on the Nature Trails in the Brecksville and North Chagrin Metropolitan Parks.

American Hornbeam — *Carpinus caroliniana* Walt.

A common understory tree of moist woods in many locations. A tree of the eastern U. S. and southern Canada. Examples may be seen on the Nature Trails in the Brecksville and North Chagrin Metropolitan Parks.

American Beech — *Fagus grandifolia* Ehrh.

Formerly one of the most common trees of the region, forming, with sugar maple, the climatic climax forest which covered large portions of the uplands. A tree of moist locations, not too dry nor too wet. A tree of the eastern U. S. and southeastern Canada. A good example of the beech-maple climax forest may be seen about the Trailside Museum in the North Chagrin

Metropolitan Park. A striking example of the differences in growth-form between forest-grown and open-grown trees may be noted by comparing with these an open-grown beech standing on the north side of the Park Boulevard near the SOM Center Road entrance to the South Chagrin Metropolitan Park. (see Fig. 13).

Chestnut — *Castanea dentata* (Marsh.) Borkh.

Formerly a common tree of dry ridges and on the spurs overlooking the valleys. A component of the oak-hickory and oak-chestnut forests. Common in mixed woods and transition stages of succession. Due to the ravages of the "chestnut blight" it has now entirely disappeared as a tree of any size. Many large stumps remain, and in many places suckers from these, or small seedling trees still persist. A tree of the central and northeastern U. S. and southern Ontario, it occurs here near the northern limits of its range. (see Fig. 12).

White Oak — *Quercus alba* L.

Next to the red oak, the most common of the oaks in the region. A tree of dry uplands and ridges, but tolerant of many soils. Almost pure stands formerly occupied many locations on the southern highlands. Common along the escarpment edge. A tree of the eastern U. S. and southern Canada. Some fine examples of old trees still remain in Forest Hill Park. (Figs. 7, 20).

Bur Oak — *Quercus macrocarpa* Mx.

Not uncommon in the Rocky River and Cuyahoga Valleys and along the Lake Erie shore. A tree of moist locations. A tree of the central U. S. and southern Canada, more common westerly. Two fine examples may be seen near the juncture of Parkview Road and River Road in the southeast corner of the Brecksville Metropolitan Park. A few small trees stand in the parkway just west of Coventry Road and north of South Park Boulevard, Shaker Heights.

Chestnut Oak — *Quercus montana* Willd.

Not uncommon along the edge of the escarpment, east of the Cuyahoga River. A tree of the northeastern U. S., it occurs here at the northwestern edge of its range. A component of the oak-chestnut forest and characteristic of the Appalachian Mountains. Good examples may be seen on both sides of Euclid Creek gorge, and some fine old trees still stand in Forest Hill Park, East Cleveland.

Swamp White Oak — *Quercus bicolor* Willd.

Not uncommon in wet and swampy locations on both the plateau and plain portions of the region. Often appears as a component of either upland or lowland swamp forests. A tree of the northeastern U. S. and southern

Canada. Two fine old examples stand on either side of Tinker's Creek Road not far from Canal Road. An interesting smaller tree may be seen in the small bog along the Park Boulevard where it passes the upper Shelter House in the Brecksville Metropolitan Park. (see Fig. 24).

Chinquapin Oak — *Quercus muhlenbergii* Engelm.

An occasional tree of the lake and till plains west of the Cuyahoga, in poorly drained soils. A tree of the northern central U. S. and southern Ontario, occurring here toward the eastern limits of its range. A good example may be seen on the northeastern slope of Mount Pleasant (a dissected portion of the Lake Plain) in Rocky River Valley south of Brookpark Bridge.

Common Red Oak — *Quercus maxima* (Marsh.) Ashe.

The most abundant of the oaks of the region. Widely distributed and found in many situations. A tree of mixed woods and many transition stages. A tree of the eastern U. S. and southern Canada. Good examples are numerous. Several fine trees stand along the Nature Trail in the North Chagrin Metropolitan Park. Other good examples may be seen about the lower Shaker Lake.

Black Oak — *Quercus velutina* Lam.

Common on sandy ridges and dry slopes of valley walls. A tree of the eastern U. S. and southern Canada. Good examples may be seen along most of the foot trails in the Brecksville Metropolitan Park. A medium-sized tree stands near the Trailside Museum in this park. Some fine trees stand in Forest Hill Park. Probably the largest black oak in the county stands near the Band Shell in Gordon Park, measuring 54 inches dbh.

Scarlet Oak — *Quercus coccinea* Muench.

Not uncommon on dry ridges and ravine edges and on spurs overlooking the valleys. A tree of the eastern U. S. and southern Canada. Good examples may be seen in Forest Hill Park, about the lower Shaker Lake, along the ridge trails in the Brecksville Metropolitan Park, and along the edge of the cliff on the north side of Tinker's Creek gorge in the Bedford Metropolitan Park.

Pin Oak — *Quercus palustris* Muench.

An abundant tree of the lake plain in wet situations, as well as of river bottoms and poorly drained sites on the uplands. A tree of the northern central U. S. and southern Ontario. Good examples are numerous. Two large trees stand on either side of the road leading from the main Park Boulevard in Rocky River Valley between Fort Hill and Mount Pleasant. A tree 48 inches dbh., stands just west of 13105 Detroit Avenue, Cleveland. (see Fig. 23).

Shingle Oak — *Quercus imbricaria* Mx.

Rare here. Probably occurred formerly as scattered individual trees in the oak-hickory forest. A tree of the northern central U. S., occurring here near the northern limit of its range. A good example stands on the northern edge of Chippewa Creek gorge just outside the limits of the Brecksville Metropolitan Park. Two planted specimens may be seen on the south side of North Park Boulevard, just west of Coventry Road, Cleveland Heights. Several others stand near the lagoon in Rockefeller Park, Cleveland.

American Elm — *Ulmus americana* L.

Abundant in wet bottomlands, sometimes forming pure stands in flood plain or wet upland woods. Component of both upland and lowland swamp forests. On many farms now under cultivation, elms of large size often dot the landscape or give shade and protection to the farmhouse. Usually these trees mark the places where moisture either is, or formerly was, abundant. Often planted as a roadside tree, occasionally a large specimen, out of line with the others, betrays the fact that it was already there as a native before the others arrived. A tree of the eastern U. S. and southern Canada. Large elms are so much a feature of the landscape in the open country that fine examples are easy to find. A good example of the "farmhouse elm" stands beside the white house on Wilson's Mill Road where Lander Road joins Wilson's Mill. This tree measures 60 inches dbh. (see Fig. 15).

Slippery Elm — *Ulmus fulva* Mx.

Common in bottomlands of river and stream valleys, and sometimes found on the uplands as well. A tree of the eastern U. S. and southern Canada. Good examples may be seen along the Nature Trail in the Rocky River Metropolitan Park near the Trailside Museum. A fine tree stands in the ravine near the Trailside Museum in North Chagrin Metropolitan Park.

Cork Elm — *Ulmus thomasi* Sarg.

Rare here. Occasional on the East Branch of Rocky River. A tree of the central U. S. and southern Ontario and southern Quebec, occurring here near the northeast corner of its range. Best examples of a good-sized tree just over the Cuyahoga County line in Medina County may be seen on bottomland near foot trail along east side of river on East Branch of Rocky River just above Hinckley Lake in Hinckley Metropolitan Park. A small tree grows on the Nature Trail in Brecksville Metropolitan Park.

Hackberry — *Celtis occidentalis* L.

Rare here, occurring sparingly in Rocky River Valley and perhaps elsewhere. A tree of wide distribution, its best develpoment is in the west and south. Here it appears near the northeastern limits of its main range.

Several trees may be seen at the foot of the west wall of Rocky River Valley along the Park Boulevard south of the Brookpark Bridge.

Red Mulberry — *Morus rubra* L.

Occasional only, as a small understory tree in the flood plain forest. A tree of the eastern and southern U. S. and southern Ontario, occurring here near the northern limits of its range. Several trees may be seen along the bridle path near the Trailside Museum in Rocky River Metropolitan Park. Another small specimen stands near the Trailside Museum in the Brecksville Metropolitan Park.

Cucumbertree — *Magnolia acuminata* L.

Although not present in large numbers, this tree is a regular component of the beech-maple climax forest here, either on the relatively flat uplands of the plateau, or in the ravines and gorges east, south or west of Cleveland. A tree of southern and southwestern relationships, it is here near the northern limits of its range. Fine examples may be seen in the North Chagrin, South Chagrin, and Brecksville Metropolitan Parks. The largest tree known to the writer, 46 inches dbh., is located on Center Ridge Road (north side) near the western limits of the City of Rocky River where the road crosses a small gully. This tree should be preserved as a landmark.

Tuliptree — *Liriodendron tulipifera* L.

Like the cucumbertree, this tree is a regular constituent of the beech-maple climax forest, but more common than the cucumber. Formerly it was relatively more numerous than at present, often occurring in groves. It grew to giant size. Tulip was present also along the old beach lines where it was associated with beech and ash. A tree of southerly and easterly associations, it occurs here near its northern limits. A giant tuliptree formerly growing near the present small lake in Wade Park is mentioned by Charles A. Post as a tree which "took five or six boys with outstretched arms and clasped hands to encircle it". Large old tulips still stand in Wade Park just north of the Museum of Art, as in many another location within the limits of the city. Several good examples of such old trees may be seen on East 89th Street north of Euclid Avenue. Perhaps the tuliptree may be seen in its best development as a forest tree now in the North Chagrin Metropolitan Park not far from the Trailside Museum there.

Pawpaw — *Asimina triloba* (L.) Duval.

A small tree formerly common in groves or thickets in rich bottomlands and ravines. Now limited to a few localities in river and stream valleys. A tree of southern relationships existing here near the northern limits of its range. Small thickets may still be seen along the East Branch of Rocky

River; along the Nature Trail in the Brecksville Metropolitan Park; beside the boulevard in Euclid Creek Metropolitan Park, or along the bridle path in the North Chagrin Metropolitan Park at the foot of the bluffs not far from the Trailside Museum.

Sassafras — *Sassafras variifolium* (Salisb.) Ktze.

A common tree in mixed woods or open places, sometimes growing to large size, sometimes forming thickets about old trees by the process of suckering from the roots. A tree of southern and southwestern relationships occurring here near the northern limits of its range. Good examples of large forest form may be seen in the North Chagrin Metropolitan Park along or near the Nature Trail. A tree 36 inches dbh., stands in Forest Hill Park (East Cleveland) near the foot trail on the east side of Dugway Brook ravine.

Witchhazel — *Hamamelis virginiana* L.

Sometimes occurs in small tree form, but usually as a shrub. It is common in open woods or along ravine edges in the beech-maple climax forest. A tree of the eastern U. S. and southern Canada. Good examples may be found in all Metropolitan Parks.

Sycamore — *Platanus occidentalis* L.

A common tree of the flood plain forest and of ravine bottoms, widely distributed over the area. Old trees may reach huge proportions. A tree of the eastern U. S. and southern Canada. Good examples may be seen in almost any stream bottom. For many years a large tree (over 6 feet dbh.), reputed to mark the meeting place of the Moravian missionaries with the Indians, stood by the roadside west of the Cuyahoga River near the juncture of Tinker's Creek Road and Canal Road. In 1940 the top of this tree was blasted off as a safety measure. But the great bole continues to live and produce an abundance of leafy sprouts. (see Figs. 9, 25).

Wild Black Cherry — *Prunus serotina* Ehrh.

Nowhere abundant as a large tree, but regularly found as an individual tree in most mixed woods. An early secondary succession species. A tree of the eastern U. S. and Canada. Good examples are found in all Metropolitan Parks. A tree 34 inches dbh. stands in Big Creek Parkway in ravine just north of Stumpf Road. Another, 36 inches dbh., stands near the foot of one of the spurs which touches the main Park Boulevard near lower Chippewa Creek in the Brecksville Metropolitan Park.

Choke Cherry — *Prunus virginiana* L.

A rather common shrub or small tree at the edges of woods or fields, or along roadsides, or as an understory shrub in open places in the forest, or on hillsides. In late May it is conspicuous by reason of its racemes of white

bloom. A tree of the eastern U. S. and Canada. Examples may be seen along most country roadsides or at the edges of woods.

Fire Cherry — *Prunus pennsylvanica* L.

A small tree occurring along roadsides, woods edges, or on the Lake Erie shore. A tree of northern affiliations occurring here near the southern limits of its range, except as it may appear at higher elevations in the Appalachians. A small thicket may be seen along the bridle path just west of Coventry Road and north of South Park Boulevard, Shaker Heights.

Wild Plum — *Prunus americana* Marsh.

Usually found forming thickets in bottomlands. Mentioned by Alfred Wolcott in 1811 as characteristic of the "Cuyahoga bottoms". An extensive thicket was known to have occurred in the valley of Baldwin Creek a generation ago. At the present time a rare tree here. A tree of the eastern U. S. reaching its northerly limits about the more southerly of the Great Lakes. A good example of a wild plum thicket may be seen just over the Cuyahoga County line in Medina County at the southern end of Hinckley Lake.

Hawthorn — *Crataegus* L. ssp.

The hawthorns are a group of exceptionally difficult trees from the standpoint of taxonomy. Even the specialists reach widely different conclusions. In Cuyahoga County there may be from 15 to 20 species. In view of the confusion now existing with regard to their classification it seems best in include them in this list under one general head. As a group, the thorns constitute a strong element in early secondary succession stages. With the crabs and sumacs they quickly occupy abandoned fields. They also appear in dry open woods, along woods edges, and river banks. They are among the very common small trees of the region.

Some idea of the possible species occurring in Cuyahoga County may be gained from the following list of specimens collected by Mr. F. J. Tyler in adjoining Lake, Portage, and Geauga Counties (most of them in the neighborhood of Painesville, Lake County). These have all been determined by Dr. Ernest J. Palmer of the Arnold Arboretum.

Found in Lake County

Crataegus pruinosa K. Koch
Crataegus calpodendron (Ehrle) Medic.
Crataegus assurgens Sarg.
Crataegus ovatafolia Sarg.
Crataegus punctata Jacq.
Crataegus sera Sarg.
Crataegus Pringlei Sarg.
Crataegus crus-galli L.

Crataegus leptophylla Sarg.
Crataegus Kellermanii Sarg.
Crataegus latisepala Ashe.
Crataegus tenella Ashe.
Crataegus cuneiformis pausiaca Ashe.
Crataegus gaudens Sarg.
Crataegus dissona Sarg.
Crataegus compacta
Crataegus pedicillata albicans Ashe.
Crataegus pedicellata Robesoniana Sarg.
Crataegus structilis Ashe.
Crataegus macrosperma Ashe.

Found in Portage County
Crataegus disperma Ashe.
Crataegus succulenta Schrad.
Crataegus Porteri Britton.
Crataegus calpodendron (Ehrle) Medic.

Found in Geauga County
Crataegus brumalis Ashe.
Crataegus punctata Jacq.

American Crab — *Malus coronaria* (L.) Mill.

A tree of abandoned fields and woods edges. Its area of distribution is centered about the Great Lakes. A common secondary succession species.

Shadbush — *Amelanchier canadensis* (L.) Med.

Occurs on hillsides and woods edges in dry locations, often in beech-maple or oak-hickory forest along ravine edges or on spurs. A tree of the eastern U. S., reaching nearly to its northern limits here. Not uncommon. Particularly conspicuous when in bloom in early May before the appearance of the leaves on the forest trees. Good examples of relatively large trees may be seen in Rocky River Valley at foot of slope on westerly side of Fort Hill, in the Brecksville Metropolitan Park near end of spur which touches the main boulevard near the lower portion of Chippewa Creek, in open field near the intersection of Cedar and Lander Roads, Mayfield Heights.

Honeylocust — *Gleditsia triacanthos* L.

Rare here. Like the coffeetree (below), it is a tree of river bottoms and lake shores, occupying much the same range, and with much the same growth habits. Several medium-sized trees may be seen at the western end of Puritas Springs Road Bridge on the river bank just within the Metropolitan Park entrance in Rocky River Valley. These are the natural progeny

of a very large old tree that until 1937 stood nearby.

Kentucky Coffeetree — *Gymnocladus dioica* (L.) K. Koch.

Rare here. A tree of river bottoms usually growing as a solitary tree or in small groups. A tree of western and southwestern relationships, it occurs here near the northeastern corner of its range. Examples may be seen near the northwestern corner of the intersection of Mastick and Puritas Springs Roads, Rocky River Valley. These, however, are planted trees.

Northern Pricklyash — *Zanthoxylum americanum* Mill.

Uncommon here. A small tree or shrub formerly probably only of occasional occurrence as an understory tree of open forests or along stream banks. A tree of more westerly relationships, occurring here near the eastern limits of its range. Good examples are rare. One location is on the upper edge of Doan Brook ravine near Chestnut Hills Drive.

Hoptree — *Ptelea trifoliata* L.

A small tree or shrub found most frequently here growing on the sand dunes of the Lake Erie shore. A tree of southern and southwestern relationships, occurring here near the northern limits of its range. Occasional examples may be found along the lake shore east of Gordon Park, and on the Nature Trail in that park.

Staghorn Sumac — *Rhus typhina* L.

A small tree of waste places and abandoned fields. Common along roadsides. One of the earliest arrivals in the process of secondary succession. A tree of the northeastern U. S. and southern Canada. Common along country roadsides.

Smooth Sumac — *Rhus glabra* L.

A small tree of much the same habit and affiliations as staghorn sumac, but not so common. Good examples of this and the above species may be seen near the Trailside Museum in the Rocky River Metropolitan Park.

Poison Sumac — *Rhus vernix* L.

A small tree of bogs and swamps or wet grounds. Rather common in such locations. A tree of the eastern U. S. and southern Canada. Keep away from it!

Wahoo — *Euonymous atropurpureus* Jacq.

A small tree of the river bottoms occurring as an understory tree of the flood plain forest. Not uncommon in Rocky River Valley. A tree of the west and southwest, it occurs here near the northeastern corner of its range.

A few examples may be seen at the south side of the ford which crosses the Rocky River near the Detroit Avenue entrance to the Metropolitan Park.

Sugar Maple — *Acer saccharum* Marsh.

Most abundant of the maples here, forming, with beech, the climatic climax forest of the region. Even on completely cleared and open land, the presence of large sugar maples as roadside trees of the neighborhood is a reminder of its former abundance, not only on the plateau but also on many parts of both the lake and the till plains. A tree of the U. S. and southern Canada east of the prairies. Many fine examples may be seen along country roadsides and in the Metropolitan Parks. A large tree (37 inches dbh.) may be seen in a small area of woodland on the north side of Mayfield Road just east of SOM Center Road. Perhaps the largest sugar maple in the county stands by the roadside in front of the small cemetery on Butternut Ridge Road just east of the Village of North Olmsted. In 1948 this tree measured 53 inches dbh. Another large tree of this species may be seen in Forest Hill Park at the head of Dugway Brook ravine near the corner of Lee and Monticello Boulevards. (see Fig. 8).

Black Maple — *Acer nigrum* Mx. f.

Comparable to the sugar maple in size and appearance, this tree is found in moist situations in river and stream bottoms. It is fairly common here in such locations. Abundant in Rocky River Valley, appearing also in lesser degree in the Cuyahoga and Chagrin Valleys. A tree of the eastern U. S. and southern Canada, it occupies much the same range as the sugar maple, but does not go so far south, north, east, or west. Good examples may be seen along the Nature Trail, or generally in the neighborhood of the Trailside Museum in the Rocky River Metropolitan Park.

Silver Maple — *Acer saccharinum* L.

One of the dominants of the lowland swamp forest, occurring in low swampy places along the lake plain, in river valleys, and along stream edges. Formerly more abundant as a native tree than now. A tree of the eastern and southern U. S. and southern Canada. A good example of a large old tree may be seen on the south side of the ford crossing the Rocky River near the Detroit Avenue entrance to the park. Perhaps the largest silver maple in the county stands at the rear of the house at 33 East 194th Street, City of Euclid. This measures 54 inches dbh. (see Fig. 11).

Red Maple — *Acer rubrum* L.

Next to the sugar maple the most abundant of the maples here. Grows in many situations but prefers moist locations. With the American elm and black ash it is one of the dominants of the upland swamp forest. Frequently identified with the beech-maple climax, it is often found in association with

those trees. It often appears in large size as a tree of country roadsides. A tree of the eastern U. S. and southern Canada. A fine example of an open-grown tree stands opposite the Harriet Keeler Memorial Garden on the northerly side of the Park Boulevard in the Brecksville Metropolitan Park. Fine trees of forest form may be seen along the Nature Trail in the North Chagrin Metropolitan Park, as well as along most country roadsides. (see Fig. 17).

Boxelder — *Acer negundo* L.

This maple is abundant as a component of the flood plain forest in Rocky River Valley. Also a tree of the lowland swamp forest on the Lake Plain west of the Cuyahoga. A tree of the eastern U. S. and southern Canada growing along the borders of streams and lakes, appearing here near the northeastern limits of its range. Good examples may be seen along the Nature Trail, or generally in the vicinity of the Trailside Museum in the Rocky River Metropolitan Park.

Mountain Maple — *Acer spicatum* Lam.

A small tree of cool rocky gorges, especially along the face of the Portage Escarpment. Rare now, probably much more common formerly. A tree of northern affiliations occurring here at the southern limits of its range, except as it may grow at higher altitudes in the Appalachians. Examples may be seen in Doan Brook gorge near the head of Delaware Road, Cleveland Heights, or in Tinker's Creek gorge (north side and eastern end) along the foot trail near the base of the cliffs.

Ohio Buckeye — *Aesculus glabra* Willd.

A common tree in Rocky River Valley as a component of the flood plain forest. Occasional elsewhere. A tree of the eastern central U. S. reaching its northern limit here. Frequent examples may be seen along the bridle path in the Rocky River Metropolitan Park south of Mastick Road.

Basswood — *Tilia americana* L.

Common but not abundant in moist locations in mixed woods, often growing in clumps of several trunks together. Often found in ravine bottoms. A tree of the northern and middle U. S. and southern Canada east of the prairies. Good examples may be found in all Metropolitan Park Reservations. A fine large tree stands on the Nature Trail in the Bedford Reservation.

Herculesclub — *Aralia spinosa* L.

A small tree apparently occurring only occasionally here in moist ravines. Native to the southeastern U. S., at its extreme northern limits here. The only two specimens known to the writer, which were trees of considerable size, apparently indigenous, were both found in ravines in the Chagrin Valley. Largely planted as an ornamental, good specimens may be seen in Forest Hill Park, East Cleveland.

Tupelo — *Nyssa sylvatica* Marsh.

A rather common tree in association with the beech-maple climax, especially on the spurs overlooking the Chagrin Valley; also associated with pin oak and lowland swamp forests in wet locations. A tree of the eastern U. S. Some fine specimens can be seen in the North Chagrin Metropolitan Park near the Trailside Museum.

Flowering Dogwood — *Cornus florida* L.

A common small tree occurring most frequently in association with oak-hickory woodlands, but common also along woods edges everywhere; often appearing in open abandoned fields. A tree of the eastern U. S. and southern Ontario. May be seen to good advantage when it is in bloom in early May in the Brecksville Metropolitan Park.

Alternate-leaved Dogwood — *Cornus alternifolia* L.

Usually a smaller tree than the foregoing, it is also less common and apt to be overlooked in the forest, where it grows in open places or along woods edges. A tree of the northeastern U. S. and southeastern Canada. A good-sized specimen can be seen on the east side of Rocky River about opposite the Mastick Road picnic grounds.

White Ash — *Fraxinus americana* L.

In the beech-maple climax forest this tree occurs regularly as a tree of secondary succession origin. It is a member of most transition stages and of mixed forests. It occurred formerly with oak along the old beach lines. A tree of the eastern half of the U. S. and southern Canada. Excellent examples may be seen in all of the Metropolitan Parks. A very old tree stands near the house at 10013 Detroit Avenue (49 inches dbh.). Another (29 inches dbh.) stands in Forest Hill Park in Dugway Brook ravine about opposite Glenmont Road. (see Fig. 22).

Red Ash — *Fraxinus pennsylvanica* Marsh.

A tree of moist situations, like river banks or pond or swamp edges. Sometimes a component of the swamp forest in its later transition stages. Not readily recognized without close scrutiny, it is probably more common than it appears to be. Found in Rocky River, Cuyahoga and Chagrin Valleys. A tree of the eastern and middle U. S. and southern Canada east of the prairies. A fine large tree may be seen near the Chagrin River edge at Gates Mills near the Town Hall. Rather common in Rocky River Valley.

Black Ash — *Fraxinus nigra* Marsh.

Usually found in swamp forests with American elm and red maple or silver maple. Also occurs in wet situations in river and stream valleys.

Normally a tree of deep, cold northern swamps and low banks of streams and lakes. An excellent example may be seen at the edge of the bridle path near the Forest Lane entrance to the North Chagrin Metropolitan Park. In the same general location are a few smaller trees. Another good example stands on the east side of the Park Boulevard in Rocky River Valley just north of the Hilliard Bridge. In the Brecksville Metropolitan Park two good-sized trees may be seen in the bottom of the small ravine near the Trailside Museum. (see Fig. 16).

Nannyberry — *Viburnum lentago* L.

A small tree or shrub, not very abundant here, occurring in open, rather moist situations. A tree of southern Canada and northeastern U. S. A good example may be seen in the North Chagrin Metropolitan Park on the west side of the River Road and east of the River Road entrance to the park.

Black Haw — *Viburnum prunifolium* L.

This small tree is rare here, but may occasionally be found as a tree of woods edges or open places in woodlands. A tree of the northeastern U. S.

INTRODUCED TREES

II.

Because of their frequent occurrence as street trees or ornamentals on lawns, the following list of the more common or more fully established exotic species in the Greater Cleveland region is given.

(1) TREES NATIVE TO NORTH AMERICA

Red Pine — *Pinus resinosa* Ait.

Native of southern Canada and the northeast. Extensively planted as an ornamental, and in so-called "reforestation" projects. Good examples of young trees may be seen near the Trailside Museum in the Brecksville Metropolitan Park, and in Forest Hill Park.

Jack Pine — *Pinus banksiana* Lamb.

Native of the more northerly Lake states, the northeast and Canada, growing almost to the Arctic Circle. Used for forest plantings as a pioneer on sandy or poor soils. Good examples may be seen near the Trailside Museum in the Brecksville Metropolitan Park.

Baldcypress — *Taxodium distichum* (L.) Rich.

Native of the lowlands of the southern Atlantic and Gulf coasts and lower Mississippi Valley. Although normally a tree of swamps and low bottomlands, it also grows well on drier soils. Planted here as an ornamental. Examples may be seen at 14013 and 12629 Detroit Avenue, also in the small park at Landon Road and Detroit Avenue.

Arborvitae — *Thuja occidentalis* L.

Native to southeastern Canada, the more northerly Lake states, New England and the Appalachian Mountains. Usually a tree of moist situations. Planted largely as an ornamental. A good example may be seen in Forest Hill Park, Cleveland Heights.

Gray Birch — *Betula populifolia* Marsh.

Native to New England, Nova Scotia and the St. Lawrence Valley, New York, New Jersey, eastern Pennsylvania and Delaware. A tree of waste places, and throughout its range an early arrival in the progress of secondary succession. Planted here largely as an ornamental. Two small trees may be seen near the artificial lake in Forest Hill Park.

Red Birch — *Betula nigra* L.

Native to the eastern U. S., except in the mountains, largely south of the Great Lakes, common in central and southern Ohio as a tree of stream edges and river banks. Planted here as an ornamental, some good examples may be seen in the parkway south of North Park Boulevard just west of Coventry Road, Cleveland Heights.

Osageorange — *Maclura pomifera* (Raf.) Schw.

Native to the bottomlands of southeastern Oklahoma and Texas, and southwestern Arkansas. Extensively planted here as a hedge plant in the days before wire fences. It served this purpose well because of its thorny and tough branches. To the east of Cleveland old hedges of osageorange are not uncommon. Large individual trees are rare however. Several may be seen in the Monroe Avenue Cemetery on the west side, and a single isolated tree stands at the corner of Fairmount Boulevard and Lander Road, Shaker Heights.

Sweetgum — *Liquidambar styraciflua* L.

Native to the southeastern U. S., reaching its best development along stream bottoms. Planted here sometimes as a street tree, sometimes as an ornamental. A row of well developed street trees may be seen on either side of Euclid Heights Boulevard east of Kenilworth Road, Cleveland Heights. Some large thrifty specimens occupy a conspicuous place along the main driveway in the Cleveland Zoo, Brookside Park.

Redbud — *Cercis canadensis* L.

Native to the eastern and southern U. S. to the level of the Great Lakes. Not uncommon in the region of Sandusky, but apparently not native to the Cleveland region. Extensively planted as an ornamental, it may be seen in most city parks.

Black Locust — *Robinia pseudoacacia* L.

Native to the Appalachian Mountains and parts of Arkansas and eastern Oklahoma. Was early introduced to Cleveland, as an ornamental tree, being offered as a "premium" with the purchase of nursery stock. Many of these old trees still stand before farm houses. A visitor to Cleveland in 1850 noted "some fine rows of locust trees" on what is now Detroit Avenue.

Hardy Catalpa — *Catalpa speciosa* Ward.

Native to the region surrounding the juncture of the Ohio and the Mississippi Rivers. Planted extensively in the eastern U. S. as a street tree and as an ornamental. Also grown early in the history of Cleveland in groves for use as fence posts. Can be still seen on many streets, although it is gradually being replaced by more desirable species. Most heavily planted as a street tree in the region between Lorain Avenue and West 25th Street, Cleveland.

(2) TREES NATIVE TO EUROPE

Austrian Pine — *Pinus nigra* Arn.

The dominant species in the "Black Forest" of Germany. Planted extensively as an ornamental and in so-called "reforestation" projects. Good examples may be seen in Forest Hill Park; at the Forest Lane entrance to the North Chagrin Metropolitan Park; and near the Trailside Museum in the Brecksville Metropolitan Park.

Scotch Pine — *Pinus sylvestris* L.

An abundant tree of the native forests of northern Germany and Russia. Planted extensively throughout the eastern U. S. and Canada for forestry purposes. Good examples may be seen in Forest Hill Park; about the Forest Lane entrance to the North Chagrin Metropolitan Park; and near the Trailside Museum in the Brecksville Metropolitan Park.

Norway Spruce — *Picea abies* (L.) Karst.

Native to northern and central Europe. Planted extensively throughout the U. S. as a windbreak and for ornamental purposes. In the early days in Cleveland trees of this species were often offered as a premium

with orders of nursery stock and frequently old trees still occupy a place before the farm house. Good examples may be seen in Forest Hill Park.

Crack Willow — *Salix fragilis* L.

Native to Europe and Asia. Early introduced into the U. S. and Canada, and now so thoroughly established in the eastern part of the country as to appear like a native tree. This is the common large willow found along all streams in the Cleveland region. Good examples may be seen in the vicinity of the Trailside Museum in the Rocky River Metropolitan Park.

Silver Poplar — *Populus alba* L.

Native to Europe and Asia. Planted largely as an ornamental. Good examples may be seen on East Park Boulevard near the Cleveland Museum of Art, and just south of the Mastick Road picnic ground, Rocky River Metropolitan Park.

Lombardy Poplar — *Populus italica* Moench.

Native to Europe. Planted largely as an ornamental. A common tree of private estates where it is often used as a screen.

European White Birch — *Betula pendula* Roth.

Native to Europe. Planted largely as an ornamental, but disappearing because of the ravages of a boring insect.

London Planetree — *Platanus acerifolia* Willd.

A hybrid, supposedly, between the native sycamore and the oriental species. Planted extensively as a street tree because of its ability to tolerate a smoke-laden atmosphere. The second most common street tree in Cleveland. Some recent plantings can be seen on the Mall just west of the Board of Education building.

European Mountainash — *Sorbus aucuparia* L.

Native to Europe. Planted extensively as an ornamental, and now found in certain places growing wild. Good examples may be seen along the Park Boulevard in Rocky River Valley between the Hilliard and Lorain Bridges.

Norway Maple — *Acer platanoides* L.

Native to Europe. Planted extensively as a city shade tree. An unusually large isolated tree can be seen in the eastern edge of Gordon Park near St. Clair Avenue.

(3) TREES NATIVE TO ASIA

Ginkgo — *Ginkgo biloba* L.

Native to China and Japan. Planted as an ornamental. Some good-sized trees may be seen on the lawns of the old residences on the north side of Euclid Avenue between East 22nd and East 40th Streets. A fine old specimen, probably planted a century ago, stands on the grounds of Dr. Kirtland's old home at 14013 Detroit Avenue.

White Mulberry — *Morus alba* L.

Native to China. Many trees were imported to Cleveland about 1829 to serve as a food plant for silkworms. Very few large trees remain, but small trees are not uncommon along woods edges where seeds have been dropped by birds. A large specimen stands on the south side of Center Ridge Road near the western line of Cuyahoga County.

Ailanthus — *Ailanthus altissima* (Mill.) Swing.

Native to China. Introduced into the U. S. as early as 1784. Has been a Cleveland tree for well over 100 years and is now thoroughly established all over the built-up portions of the city. Originally planted as an ornamental and a street tree, it now commonly grows at the base of foundations of buildings, along fences or walls, and in abandoned lots, propagating itself by its wind-borne seeds. Some of the largest ailanthus trees in Cleveland grow in the Monroe Avenue Cemetery.

Horsechestnut — *Aesculus hippocastanum* L.

Native to southern Asia. Extensively planted as an ornamental. Good examples are numerous.

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